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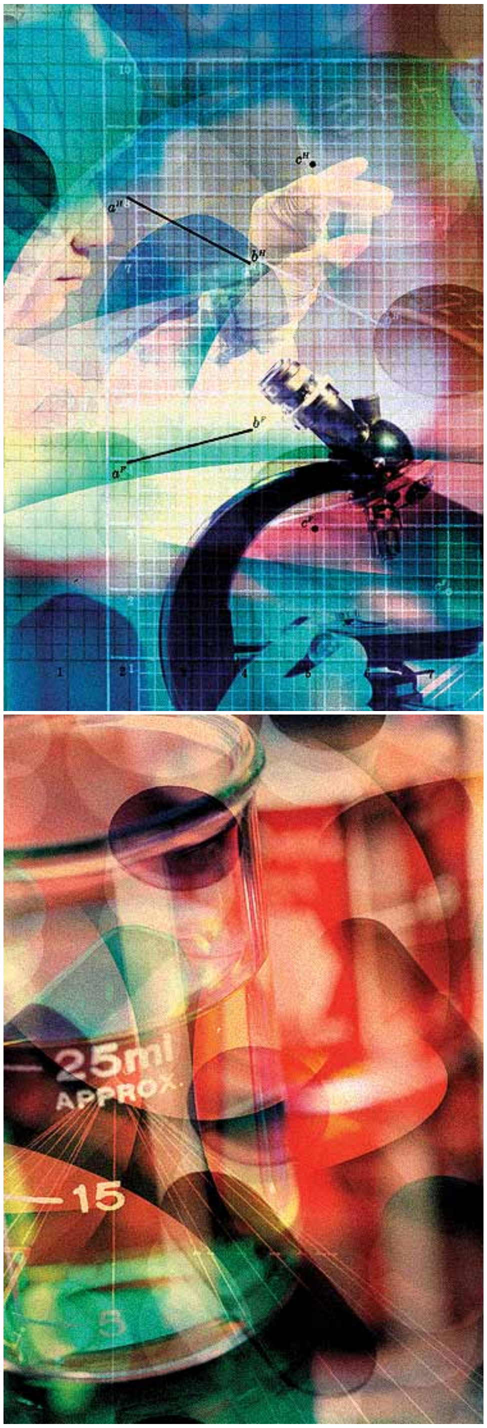

Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

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

2007

Canada

Healthy Canadians and communities in a healthier world

Public Health Agency of Canada

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2007

Contributors to CIPARS 2007

These acknowledgements are intended to identify and thank the numerous individuals and organizations that have contributed to the success of CIPARS in 2007.

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- Canadian Poultry and Egg Processors Council
- CIPARS National Steering Committee on Antimicrobial Resistance Surveillance in Enterics
- CIPARS Farm Swine Advisory Committee

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Executive Summary

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) tracks temporal and regional trends in antimicrobial use, and antimicrobial resistance in selected species of enteric bacteria obtained at different points along the food chain and from human cases. This information supports the creation and evaluation of policies to contain antimicrobial resistance and to better manage antimicrobial use in human medicine, veterinary medicine, and agricultural sectors.

The CIPARS Annual Report highlights the resistance profiles of antimicrobials considered to be of Very High Importance in Human Medicine (Category I in the classification system used by the Veterinary Drug Directorate of Health Canada). Such drugs include the third generation cephalosporin ceftiofur, which is a veterinary antimicrobial that is closely related to ceftriaxone used to treat certain types of infections in humans, including severe salmonellosis in children; and the fluoroquinolone ciprofloxacin, which is a broad-spectrum antimicrobial recommended as first-line treatment for many human infections, including severe gastrointestinal illness.

From 2002 through 2007, resistance to ampicillin-amoxicillin/clavulanic acid-ceftiofur-cefoxitin (A2C-AMP resistance pattern) was detected in numerous *Salmonella* isolates recovered from human cases, food animals, and meat samples. The A2C-AMP resistance pattern was most commonly found in *Escherichia coli* as well as in *Salmonella* chicken isolates, particularly those of *Salmonella* Kentucky and Heidelberg.

The percentage of human clinical isolates of *S.* Typhimurium with the ACSSuT resistance pattern has significantly decreased from 21% in 2003 to 10% in 2007. This decrease was likely attributable to the lower percentage of phage type 104 isolates with that resistance pattern. On the other hand, the percentage of human *S.* Typhimurium isolates with resistance to nalidixic acid was significantly higher in 2007 than in 2003. Nalidixic acid resistance is most often associated with reduced susceptibility to ciprofloxacin and can increase the risk of treatment failure with fluoroquinolones. *Salmonella* Typhi and *S.* Paratyphi A, human serovars associated with foreign travel and with no known non-human reservoir, are frequently detected with nalidixic acid resistance. The presence of nalidixic acid resistance in human *S.* Enteritidis and in other human serovars more traditionally identified as being domestically acquired (e.g. *S.* Typhimurium, *S.* Newport, and *S.* Heidelberg) is also of concern, as is the higher quantity of oral fluoroquinolones dispensed by retail pharmacies in 2007 compared to 2000. In 2007, among food animals sampled at abattoir, nalidixic acid resistance was detected in 2% of *E. coli* from chicken and none of *E. coli* from swine or beef cattle. Among retail meat samples, nalidixic acid resistance was detected in less than 1% *E. coli* in beef, 4% *E. coli* in chicken, and less than 1% *E. coli* in pork. Ciprofloxacin resistance was detected in one *Campylobacter coli* isolate from abattoir beef cattle, and in 5% of *Campylobacter* isolates and 1% of *Enterococcus* isolates from retail chicken.

The retail component of CIPARS is designed to examine inter-provincial differences in antimicrobial resistance. There were no significant differences among the provinces in percentages of isolates with resistance to any of the antimicrobials tested in retail beef or retail pork *E. coli* isolates. Statistically significant differences were observed in retail chicken *Salmonella* where we noted higher resistance to amoxicillin-clavulanic acid, ceftiofur, and cefoxitin in isolates from British Columbia than from Saskatchewan. Among chicken *E. coli*, gentamicin resistance was higher in isolates from Québec than from British Columbia, sulfisoxazole resistance was higher in isolates from Québec than from Ontario, and ampicillin resistance was higher in isolates from British Columbia than from Québec. Lastly, ciprofloxacin and nalidixic acid resistance was higher in chicken *Campylobacter* isolates from Québec than from Ontario.

With respect to antimicrobial use, the overall human consumption for 2007 decreased as measured by prescribing rates and defined daily doses (DDDs)/1,000 inhabitant-days. Category I antimicrobials continued to represent roughly 17% of the total DDDs dispensed. There were provincial differences with respect to antimicrobial consumption, including differences in consumption of fluoroquinolones, extended-spectrum penicillins, and macrolides among others. Data from the Canadian Animal Health Institute indicated the overall total kg of veterinary antimicrobials dispensed for all animals, including food animals, horses and companion animals, decreased in 2007 as compared to 2006 (8.4%). Fluoroquinolone distribution decreased compared to 2006 (25%), whereas cephalosporin distribution (inclusive of all generations) increased (21%). The significance of and reasons for these apparent changes are unknown. Surveillance of sentinel swine herds in 2007 showed that the most commonly used antimicrobials were in Category II, macrolides and lincosamides, and penicillins.

The emergence of antimicrobial resistance in common intestinal bacteria from various animal species, together with the fact that genetic elements of resistance or resistant bacteria can be transferred, respectively, between micro-organisms and between humans and other animals, strengthens the need for prudent antimicrobial use in all species across Canada. CIPARS continues to fulfill its mandate of providing scientific data and supporting the development of policies to reduce of the emergence and spread of antimicrobial resistance along the food chain.

Table 1. Summary of antimicrobial resistance surveillance findings for bacterial isolates from humans and the agri-food sector, 2007.

Species	Bacterial species	Number (%) of isolates resistant				
		Resistance to 1 or more antimicrobials	Resistance to 5 or more antimicrobials	Resistance to Category I [a] antimicrobials	Resistance to NAL, reduced susceptibility to CIP, or intermediate susceptibility to CRO	Number of different resistance patterns / number of isolates resistant
Surveillance of Human Clinical Isolates						
Humans	*Salmonella*	952/3,308 (29%)	189/3,308 (6%)	AMC: 76/3,308 (2%) CIP: 8/3,308 (< 1%) TIO: 70/3,308 (2%) CRO: 7/3,308 (< 1%)	NAL: 383/3,308 (12%) RSCIP: 411/3,308 (12%) ISCRO: 61/3,308 (2%)	125/952
Farm Surveillance						
Pigs	*Escherichia coli*	1,356/1,575 (86%)	(194/1,575) 12%	AMC: 22/1,575 (1%) TIO: (7/1,575) (< 1%)	NAL: 4/1,575 (< 1%) ISCRO: 3/1,575 (< 1%)	87/1,356
	Salmonella	61/110 (55%)	25/110 (23%)			15/61
	Enterococcus	951/985 (97%)	387/985 (39%)	CIP: 13/985 (1%) QDA: 150/336 (45%)	N/A	104/951
Abattoir Surveillance						
Beef cattle	*Escherichia coli*	77/188 (41%)				15/77
	Campylobacter	48/73 (66%)		CIP: 1/73 (1%)	N/A	3/48
Chickens	*Salmonella*	112/206 (54%)	14/206 (7%)	AMC: 25/206 (12%) TIO: 25/206 (12%)	ISCRO: 13/206 (6%)	17/112
	Escherichia coli	138/180 (77%)	38/180 (21%)	AMC: 48/180 (27%) TIO: 47/180 (26%)	NAL: 4/180 (2%) RSCIP: 3/180 (2%) ISCRO: 26/180 (14%)	53/138
Pigs	*Salmonella*	65/105 (62%)	27/105 (26%)	AMC: 1/105 (1%) TIO: 1/105 (1%)	ISCRO: 1/105 (1%)	24/65
	Escherichia coli	76/93 (82%)	11/93 (12%)	AMC: 1/93 (1%) TIO: 1/93 (1%)		31/76
Retail Meat Surveillance						
Beef	*Escherichia coli*	69/501 (14%)	10/501 (2%)	AMC: 2/501 (< 1%) TIO: 1/501 (< 1%)	NAL: 2/501 (< 1%) RSCIP: 2/501 (< 1%)	24/69
Chicken	*Salmonella*	179/346 (52%)	10/346 (3%)	AMC: 35/346 (10%) TIO: 36/346 (10%)	ISCRO: 23/346 (7%)	24/179
	Escherichia coli	295/402 (73%)	78/402 (19%)	AMC: 92/402 (23%) TIO: 74/402 (18%) CRO: 1/402 (< 1%)	NAL: 15/402 (4%) RSCIP: 15/402 (4%) ISCRO: 24/402 (6%)	94/295
	Campylobacter	140/253 (55%)	4/253 (2%)	CIP: 13/253 (5%)	N/A	8/140
	Enterococcus	383/420 (91%)	81/420 (19%)	CIP: 6/420 (1%) QDA: 22/420 (69%)[b]	N/A	48/383
Pork	*Escherichia coli*	135/297 (45%)	18/297 (6%)	AMC: 3/297 (1%) TIO: 2/297 (1%)	NAL: 1/297 (< 1%) RSCIP: 1/297 (< 1%)	36/135
Surveillance of Animal Clinical Isolates						
Cattle	*Salmonella*	35/140 (25%)	22/140 (16%)	AMC: 3/140 (2%) TIO: 3/140 (2%)	ISCRO: 2/140 (1%)	14/35
Chickens	*Salmonella*	28/105 (27%)	4/105 (4%)	AMC: 14/105 (13%) TIO: 14/105 (13%) CRO: 1/105 (1%)	ISCRO: 8/105 (8%)	11/28
Pigs	*Salmonella*	141/187 (75%)	82/187 (44%)	AMC: 4/187 (2%) TIO: 4/187 (2%)	ISCRO: 4/187 (2%)	39/141
Turkeys	*Salmonella*	42/49 (86%)	11/49 (22%)	AMC: 24/49 (49%) TIO: 24/49 (49%)	ISCRO: 24/49 (49%)	18/42
Horses	*Salmonella*	56/67 (84%)	53/67 (79%)	TIO: 2/67 (3%)	RSCIP: 44/67 (66%)	12/56

Blank cells represent values equal to 0 (0%). N/A = not applicable.

AMC = Amoxicillin-clavulanic acid. CIP = Ciprofloxacin. CRO = Ceftriaxone. ISCRO = Intermediate susceptibility to ceftriaxone. NAL = Nalidixic acid. QDA = Quinupristin-dalfopristin. TIO = Ceftiofur. RSCIP = Reduced susceptibility to ciprofloxacin.

[a] Categorization of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate of Health Canada (see Appendix A.1).

[b] Excluding *Enterococcus faecalis* (n = 388).

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Preamble

About CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS), created in 2002, is a national program dedicated to the collection, integration, analysis, and communication of trends in antimicrobial use and resistance, in selected bacteria from humans, animals, and animal-derived food sources across Canada. This information supports (i) the creation of evidence-based policies for antimicrobial use in hospitals, communities, and food-animal production with the aim of prolonging the effectiveness of these drugs and (ii) the identification of appropriate measures to contain the emergence and spread of resistant bacteria among animals, food, and people. This publication represents the 6th annual CIPARS report released by the Government of Canada under the coordination of the Public Health Agency of Canada.

CIPARS Objectives

- Provide a unified approach to monitor trends in antimicrobial resistance and antimicrobial use in humans and animals.
- Disseminate timely results.
- Generate data to facilitate assessment of the public health impact of antimicrobials used in humans and agricultural sectors.
- Provide data that permit accurate comparisons with data from other countries that use similar surveillance systems.

CIPARS 2007 Activities

In 2007, CIPARS included 2 passive and 3 active components for surveillance of antimicrobial resistance, and 2 components (humans and animals) for surveillance of antimicrobial use (Figure 1):

Surveillance of Human Clinical Isolates, which involved passive surveillance of human clinical *Salmonella* isolates at the provincial/territorial level and participation of all Provincial Public Health Laboratories across the country.

Farm Surveillance, which was implemented in January 2006, included swine herds in the 5 major pork-producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). This surveillance component involved the participation of the Alberta Ministry of Agriculture and Rural Development and the Saskatchewan Ministry of Agriculture. A sentinel farm framework was used to organize the active collection of pooled fecal samples from pigs, the provision of generic[4] *Escherichia coli*, *Enterococcus*, and *Salmonella* isolates for antimicrobial susceptibility testing, and the collection of antimicrobial use data.

Abattoir Surveillance, which involved active sample collection and analysis of *Salmonella* and generic *E. coli* from the caecal contents of healthy chickens and pigs and of *Campylobacter* and generic *E. coli* from healthy beef cattle across Canada.

Retail Meat Surveillance, which involved active sample collection and analysis of generic *E. coli, Enterococcus, Salmonella*, and *Campylobacter* in retail chicken and of generic *E. coli* in beef and pork from British Columbia, Saskatchewan, Ontario, and Québec. *Salmonella* was also recovered from pork samples, but because of the low prevalence of *Salmonella* detected in pork, this report does not include antimicrobial susceptibility results for the few isolates that were recovered.

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[4] *Escherichia coli* were identified by use of biochemical tests. No attempt was made to distinguish pathogenic strains of *E. coli* from non-pathogenic strains.

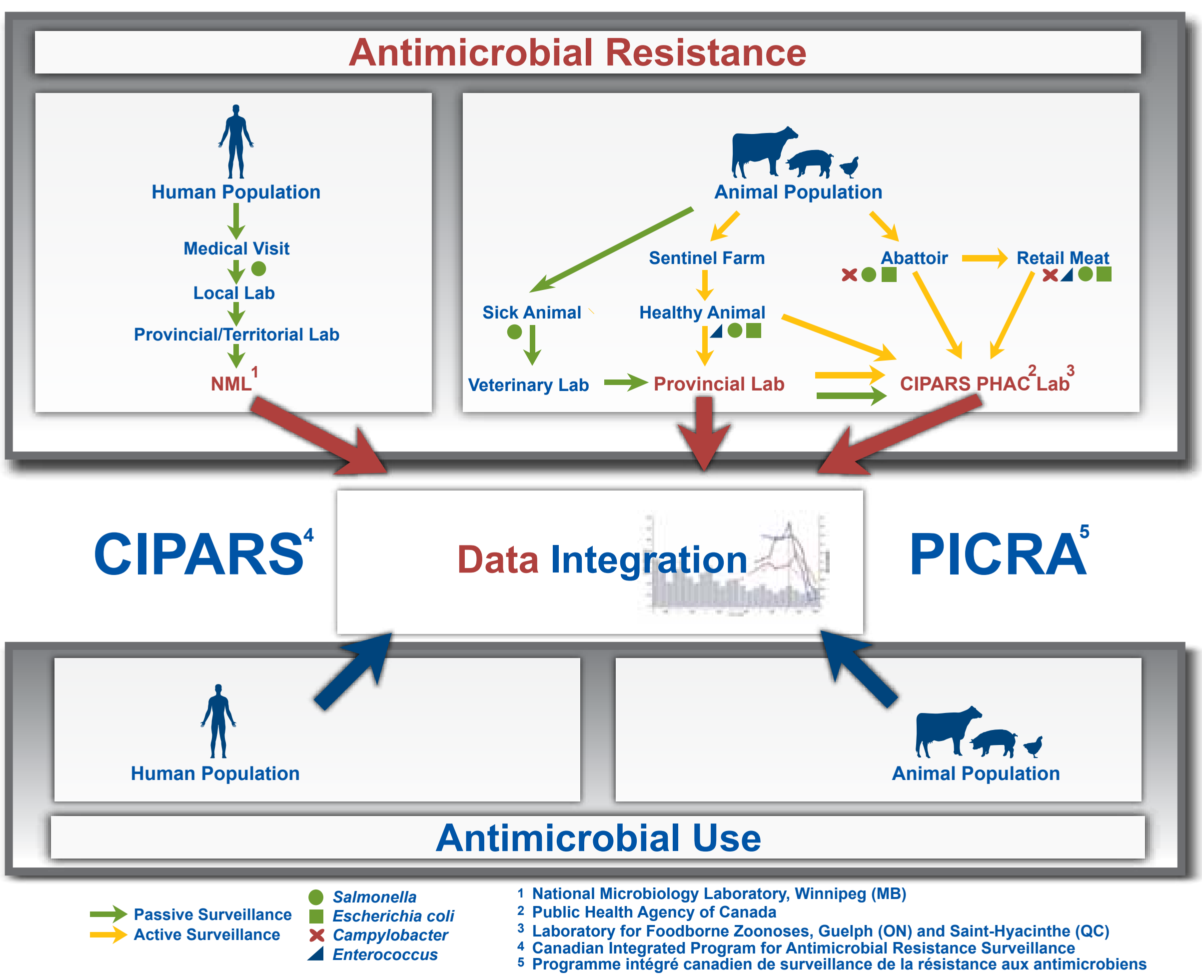
Surveillance of Animal Clinical Isolates, which involved passive surveillance of clinical *Salmonella* isolates from animals in multiple provinces and participation of the Réseau des laboratoires de l'Institut national de santé animale for the serotyping of isolates from Québec. Samples were originally submitted by veterinarians or producers to local or provincial laboratories and may have also included samples from animal feed, the animal's environment, or non-diseased animals from the same herd. Cattle isolates may have included those from both dairy and beef cattle. Chicken isolates may have included those from both layer hens and broiler chickens.

Salmonella isolates recovered from *Feed and Feed Ingredients* samples were obtained from Government and Industry Monitoring programs and from *Passive Surveillance*. Here we report on isolates recovered from 2001 through 2007.

Antimicrobial-use data in humans, obtained from the Canadian CompuScript dataset and provided by Intercontinental Medical Statistics Health, are reported for 2000 through 2007. This dataset includes information on prescriptions dispensed by Canadian retail pharmacies.

Antimicrobial-use data in animals, obtained from the Canadian Animal Health Institute and analysed by Impact Vet, are reported for 2006 and 2007 as total kilograms of antimicrobials distributed by Canadian companies for use in food, sporting, and companion animals and fish. Antimicrobial-use data were also collected in swine herds through questionnaires completed by veterinarians, owners, or managers of the herds. Questionnaires captured information on antimicrobials use (in water, feed, and injections) within each herd, health status of pigs, and farm characteristics.

Figure 1. Diagram of CIPARS surveillance components in 2007.



What's new in the 2007 Report

Changes to CIPARS

- In British Columbia, short retail meat pilot projects were conducted in 2005 and 2006. In 2007, pilot retail sampling activities were expanded to achieve more samples than previously collected for this province. Regular, year-round retail meat surveillance was initiated in British Columbia in 2008 with samples being collected every other week.
- Results for horse clinical isolates received in 2007 were added to the *Surveillance of Animal Clinical Isolates* section.
- Results for *Feed and Feed Ingredients* isolates received from 2001 to 2007 were added as a separate surveillance component.
- Data are now available separately for Newfoundland and Labrador and Prince Edward Island for the monitoring of drug consumption in humans.

Methodological changes

- For antimicrobial susceptibility testing of *Enterococcus*, bacitracin (Category III antimicrobial; Appendix A.1) was removed from the panel of antimicrobials, and tigecycline (Category I antimicrobial) was added.
- To harmonize comparison of CIPARS results with those of the National Antimicrobial Resistance Monitoring System of the United States, new *Enterococcus* resistance breakpoints were adopted in 2007 for lincomycin (from ≥ 32 to ≥ 8 μg/mL) and kanamycin (from ≥ 512 to ≥ 1,024 μg/mL). The change had little or no impact on the percentage of isolates resistant to kanamycin; however for lincomycin, the change resulted in an increase of non-*faecalis* isolates deemed resistant, from 69% to 98% in retail chicken surveillance, and from 74% to 95% in pigs farm. In this report, the new breakpoints were applied to current and all historical data before generating graphs of temporal variations.
- In 2007, a new *Salmonella* recovery method was adopted for the *Retail Meat Surveillance* component, which resulted in an increase in the proportion of isolates recovered. This new recovery method is described in the Methods section (Appendix A.3).

Important Notes

Antimicrobial Groupings and Labels:

- Antimicrobials were categorized on the basis of importance in human medicine (Veterinary Drugs Directorate of Health Canada; categories revised in November 2006; Appendix A.1). Antimicrobials are generally listed first according to this classification, and then alphabetically.
- All of the Category I antimicrobials (Very High Importance to Human Medicine) are highlighted throughout the report being: amoxicillin-clavulanic acid, ceftiofur,[5] ceftriaxone, ciprofloxacin, daptomycin, linezolid, quinupristin-dalfopristin,[6] telithromycin, and vancomycin.

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[5] Ceftiofur is licensed for use in animals only. The breakpoint for resistance to ceftiofur is lower than that for resistance to ceftriaxone. Resistance to ceftiofur is generally detected in combination with cross-resistance to amoxicillin-clavulanic acid, cefoxitin, and ampicillin and intermediate susceptibility or resistance to ceftriaxone. In this report, this resistance pattern is abbreviated as A2C-AMP.

[6] Quinupristin-dalfopristin is not effective against *Enterococcus faecalis* because *E. faecalis* is intrinsically resistant to this antimicrobial.

- Intermediate susceptibility to ceftriaxone[7] and reduced susceptibility to ciprofloxacin[8] are also highlighted. The classification “intermediate susceptibility” refers to the minimum inhibitory concentration (MIC)[9] range designated as intermediate by the Clinical and Laboratory Standards Institute (CLSI). This range appears between the dotted and solid vertical lines in the MIC distribution tables in Appendix B. The expression “reduced susceptibility” used with ciprofloxacin designates an MIC from 0.125 to 2 µg/mL for the Enterobacteriaceae *E. coli* and *Salmonella*.

- Resistance to nalidixic acid is highlighted in *E. coli* and *Salmonella*. Additionally, we highlight cases when an isolate has reduced susceptibility to ciprofloxacin[10] (a fluoroquinolone) or resistance to ciprofloxacin but no resistance to nalidixic acid because these isolates may present different resistance determinants than those having both nalidixic acid resistance and reduced susceptibility or resistance to ciprofloxacin.

- In the reporting of results for daptomycin and florfenicol, the term “non-susceptible to” was adopted instead of “resistant to” because these antimicrobials do not have defined resistance breakpoints (Appendix B).

- “Selected antimicrobials” in the temporal variations analyses are a subset of the antimicrobials tested and they were chosen as representatives of different antimicrobial structural classes (Appendix A.4). For *E. coli* and *Salmonella*, selected antimicrobials included: ampicillin, ceftiofur, gentamicin, nalidixic acid, streptomycin, tetracycline, and trimethoprim-sulfamethoxazole. For *Campylobacter*, selected antimicrobials included azithromycin, florfenicol, gentamicin, nalidixic acid, and tetracycline. For *Enterococcus*, selected antimicrobials included ciprofloxacin, erythromycin, gentamicin, quinupristin-dalfopristin, streptomycin, tetracycline, and tylosin.

- For the human antimicrobial use data, antimicrobials were additionally classified by the international standard Anatomic Therapeutic Chemical (ATC) class.

- For the animal antimicrobial use distribution data provided by the Canadian Animal Health Institute (CAHI), the information was provided to CIPARS in aggregate classes as presented.

Additional Notes:

- Antimicrobial abbreviations used in this report are defined in Appendix C.1 and C.2.

- In general, temporal variations in percentages of isolates resistant to selected antimicrobials were identified by comparing results for 2007 with those for 2003 (the year most surveillance components of CIPARS began). For data on ceftiofur and ampicillin resistance from chicken and human *S.* Heidelberg, the year of comparison was 2004 because of a change in ceftiofur use in early 2005[11] in some chicken hatcheries (and because there is cross-resistance between ceftiofur and ampicillin). For data regarding isolates recovered from retail meat from Saskatchewan, the year of comparison was 2005 because this

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[7] Ceftriaxone is licensed for use in humans only. There is an association between intermediate susceptibility to ceftriaxone (MIC range of 16 to 32 µg/mL according to CLSI guidelines) and resistance to ceftiofur. Additionally, “*the intermediate category includes isolates with antimicrobial agent MICs that approach usually attainable blood and tissue levels and for which response rates may be lower than susceptible isolates*” (CLSI M100-S16). Therefore, resistance as well as intermediate susceptibility are highlighted in this report.

[8] Reports of ciprofloxacin treatment failure in humans with salmonellosis have contributed to a debate about the appropriateness of the ciprofloxacin resistance breakpoint used for determining antimicrobial susceptibility in *Salmonella* isolates (Aarestrup et al., 2003). The current CLSI resistance breakpoint for this antimicrobial and the one adopted in this report is ≥ 4 µg/mL. However, the Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP) has used a resistance breakpoint of ≥ 0.125 µg/mL for both *Salmonella* spp. and indicator *E. coli* since 2004 and for pathogenic *E. coli* since 2006. Because of the clinical importance of ciprofloxacin and a desire to present results in a format comparable with those of DANMAP as well, the term “reduced susceptibility” is used for ciprofloxacin MICs from 0.125 to 2 µg/mL. To obtain resistance estimates that can be compared with those from DANMAP, the percentage of *E. coli* and *Salmonella* isolates in this report with reduced susceptibility must be added to the percentage of isolates resistant to ciprofloxacin.

[9] The MIC is the lowest concentration of an antimicrobial that inhibits visible bacterial growth after overnight incubation.

[10] *“Fluoroquinolone-susceptible strains of Salmonella that test resistant to nalidixic acid may be associated with clinical failure or delayed response in fluoroquinolone-treated patients with extra-intestinal salmonellosis. Extra-intestinal Isolates of Salmonella should also be tested for resistance to nalidixic acid. For isolates that test susceptible to fluoroquinolones and resistant to nalidixic acid, the physician should be informed that the isolate may not be eradicated by fluoroquinolone treatment”* (CLSI M100-S16).

[11] http://www.phac-aspc.gc.ca/cipars-picra/heidelberg/heidelberg-eng.php

was the first year of surveillance in that province. Temporal variations for resistance in isolates recovered from retail meat from British Columbia were not assessed because adequate sampling did not begin in that province until 2007. Temporal variations were not tested for *Surveillance of Animal Clinical Isolates* and *Feed and Feed Ingredients* because the intensity of passive surveillance was unequal across years.

- In the statistical analyses of temporal variations in percentages of isolates resistant to selected antimicrobials and of differences among provinces, a value of $P \leq 0.05$ was used to indicate a significant difference between years or provinces.

- With the exception of *Enterococcus faecalis* and *E. faecium*, no attempt was made to identify the species of *Enterococcus* recovered from CIPARS samples. Unidentified species of enterococci are collectively referred to in this report as "other *Enterococcus* spp." However, when used alone, the term "*Enterococcus*" refers to all enterococci, including *E. faecalis* and *E. faecium*. Similarly, *Campylobacter coli* and *C. jejuni* were the only species of *Campylobacter* that were specifically identified; unidentified species are collectively referred to as "other *Campylobacter* spp." When used alone, the term "*Campylobacter*" refers to all species of *Campylobacter*, including *C. coli* and *C. jejuni*.

Section One - Antimicrobial Resistance

Humans

Throughout 2007, the Provincial Public Health Laboratories (PPHLs) forwarded a total of 3,396 *Salmonella* isolates (149 serovars) to the National Microbiology Laboratory, Public Health Agency of Canada for phage typing and susceptibility testing (see Appendix A.2 and Appendix A.5). Based on this collection of isolates, PPHLs did not report any cases of *Salmonella* infection in the territories (Yukon, Northwest Territories, and Nunavut). Antimicrobial resistance data were incomplete or missing for 88 isolates. Therefore, final analysis was conducted on 3,308 isolates.

Summary results are provided for the 3 most commonly isolated *Salmonella* serovars in Canada (Enteritidis, Heidelberg, and Typhimurium). *Salmonella* Newport also received attention because of past outbreaks involving multidrug-resistant strains. Although the agri-food sector is not a source of *Salmonella* Typhi, *S.* Paratyphi A, or *S.* Paratyphi B,[12] data for these serovars are also presented because they each cause severe disease in humans.[13]

Antimicrobial resistance results are presented by province because of differences in isolate submission protocols between more populated and less populated provinces (Appendix A.2). Results are also presented by province because of variation among provinces in antimicrobial use and in prevailing strains and antimicrobial resistance patterns of *Salmonella*.

Because isolation of *Salmonella* from blood or urine samples suggests patients had an invasive infection that was likely treated with antimicrobials, particular attention was paid to isolates from these sample sources. Such samples may have been submitted because of treatment failure, which could not be verified because patient records were not available. Therefore, isolates recovered from these samples were potentially more likely to be resistant than isolates from other types of samples.

In terms of age distribution, the greatest proportion of *Salmonella* isolates was from human patients aged 30 to 49 years (19.6%, 650/3,308; Table B.1.1 Appendix B). Regionally, Ontario was the province from which the largest proportion of isolates was received (44.8%, 481/3,308).

Salmonella Enteritidis

(n = 910)

Provincial incidence rates of *Salmonella* Enteritidis varied from 1.57 to 7.89 (median = 3.59) cases per 100,000 inhabitant-years (see Appendix A.5 for formula). The most common phage types (PTs) were PT 13 (31%, 285/910), PT 8 (19%, 177/910), PT 1 (9%, 81/910), and PT 4 (8%, 74/910). Three percent (23/910) of isolates were recovered from blood and 2% (17/910) were recovered from urine (Table B.1.2 in Appendix B).

Antimicrobial Resistance: Results are presented in Table 2 and Table B.1.3 (Appendix B). One *S.* Enteritidis isolate was resistant to ampicillin, ceftiofur, and ceftriaxone. Reduced susceptibility to ciprofloxacin was detected in 19% (169/910) of isolates. Resistance to nalidixic acid was detected in 18% (167/910). None of the isolates had intermediate susceptibility to ceftriaxone, and none were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 20% (185/910) of all *S.* Enteritidis isolates. Resistance to 5 or more antimicrobials was detected in 1% (7/910). The most common resistance pattern was nalidixic acid alone (12%, 105/910). This resistance was mainly detected among PT 1 isolates (57%, 60/105), followed by PT 4 isolates (18%, 19/105). Thirteen percent (8/60) of PT 1 isolates were from British Columbia, 35% (21/60) were from Ontario, and 25% (15/60) were from Québec. One isolate

[12] Does not include *S.* Paratyphi B var. L (+) tartrate+, formerly called *S.* Paratyphi var. Java. The biotype of *S.* Paratyphi B included here is tartrate (-) and is associated with more severe, typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate+ is commonly associated with gastroenteritis. Because animals can be a source of this serovar, it is included under "Other Serovars."

[13] Public Health Agency of Canada, Material Safety Data Sheet – Infectious Substances. Available at http://www.phac-aspc.gc.ca/msds-ftss/msds133e.html and http://www.phac-aspc.gc.ca/msds-ftss/msds134e.html. Accessed March 2009.

from British Columbia with an atypical phage type had an AKSSuT-GEN-NAL resistance pattern. Less than 1% (5/910) of isolates (PT 1, PT 6, and PT 8) had reduced susceptibility to ciprofloxacin without resistance to nalidixic acid. Most blood (19/23) and urine (16/17) isolates were susceptible to all antimicrobials tested. Three blood isolates and 1 urine isolate were resistant to nalidixic acid. One blood isolate had a NAL-TET resistance pattern.

Temporal variations: Results are presented in Figure 2. The percentage of *S.* Enteritidis isolates with tetracycline resistance was significantly higher in 2007 (6%, 58/910) than in 2003 (3%, 11/351). For the first time since surveillance began, the following resistance patterns were detected among *S.* Enteritidis isolates: AMP-CHL-NAL-STR-SSS-SXT, AMP-TIO-CRO, CHL-NAL, CHL-NAL-TET, GEN-KAN-STR-SSS-TET, GEN-NAL, NAL-SXT, and NAL-SSS-TET-SXT. Six new phage types were identified in 2007 (PT 15, PT 19a, PT 26, PT 27, PT 37, and PT 38), and these constituted 1% (10/910) of all isolates. Eight of these isolates were susceptible to all antimicrobials tested. One PT 37 isolate was resistant to nalidixic acid alone, and 1 PT 27 isolate had an AMC-FOX resistance pattern.

The percentage of human clinical isolates of *Salmonella* Enteritidis that were resistant to tetracycline was significantly higher in 2007 (6%, 58/910) than in 2003 (3%, 11/352). For the first time since surveillance began, the AMP-TIO-CRO resistance pattern was detected.

Table 2. Resistance to antimicrobials in *Salmonella* Enteritidis isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC n = 144	AB n = 138	SK n = 38	MB n = 53	ON n = 340	QC n = 113	NB n = 39	NS n = 32	PEI n = 5	NL n = 8	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
I	Ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
I	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
II	Ampicillin	4 (3)	3 (2)	1 (3)	0 (0)	7 (2)	0 (0)	1 (3)	1 (3)	0 (0)	0 (0)	2
II	Cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	Gentamicin	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	Kanamycin	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	Nalidixic acid	26 (18)	25 (18)	5 (13)	6 (11)	59 (17)	22 (19)	10 (26)	11 (34)	2 (40)	1 (13)	18
II	Streptomycin	2 (1)	1 (1)	1 (3)	0 (0)	1 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	Trimethoprim-sulfamethoxazole	0 (0)	2 (1)	1 (3)	1 (2)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
III	Chloramphenicol	1 (1)	0 (0)	1 (3)	0 (0)	1 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1
III	Sulfisoxazole	2 (1)	2 (1)	1 (3)	1 (2)	4 (1)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1
III	Tetracycline	7 (5)	14 (10)	0 (0)	0 (0)	17 (5)	5 (4)	7 (18)	7 (22)	1 (20)	0 (0)	6
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentage for Canada corrected for non-proportional submission protocols among provinces (Appendix A.2).

Salmonella Heidelberg
(n = 319)

Provincial incidence rates of *Salmonella* Heidelberg varied from 0.63 to 6.26 (median = 1.46) cases per 100,000 inhabitant-years. The most common phage types were PT 19 (35%, 111/319), PT 29 (10%, 31/319), and PT 19a (8%, 24/319). Seven percent (22/319) of isolates were cultured from blood, and 3% (11/319) were cultured from urine (Table B.1.2 in Appendix B).

Antimicrobial Resistance: Results are presented in Table 3 and Table B.1.4 (Appendix B). Resistance to amoxicillin-clavulanic acid and to ceftiofur was detected in 15% (48/319) of *S.* Heidelberg isolates. Resistance to ceftriaxone was detected in less than 1% (1/319), and intermediate susceptibility was detected in 14% (46/319). Reduced susceptibility to ciprofloxacin was detected in less than 1% (2/319). No isolates were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 39% (126/319) of all *S.* Heidelberg isolates. Resistance to 5 or more antimicrobials was detected in 2% (5/319). The most common resistance pattern was A2C-AMP and was detected in 13% (43/319) of isolates, which mostly consisted of PT 29 (60%, 26/43) from Ontario (65%, 17/26). Three isolates had the A2C-AMP resistance pattern with additional resistance to ceftriaxone, streptomycin, or tetracycline. The A2C-ACSSuT resistance pattern was detected in 1 isolate that originated from Alberta (PT 19). Most blood isolates (14/22) and many urine isolates (5/11) were susceptible to all antimicrobials tested. The A2C-AMP resistance pattern was detected in 9% (2/22) of blood isolates (PT 19 and PT 29) and in 1 urine isolate (PT 29).

Temporal variations: Results are presented in Figure 2. The percentage of *S.* Heidelberg isolates with resistance to ceftiofur was significantly lower in 2007 (15%) than in 2004 (33%, 181/556).[14] The percentage of isolates with the A2C-AMP resistance pattern was also significantly lower in 2007 (15%, 47/319) than in 2004 (31%, 173/556). In addition, the percentage of tetracycline-resistant isolates was significantly lower in 2007 versus 2003. The percentage of isolates with intermediate susceptibility to ceftriaxone was significantly lower in 2007 (14%) than in 2004 (25%, 142/556).

The percentage of human clinical isolates of *Salmonella* Heidelberg with the A2C-AMP resistance pattern was significantly lower in 2007 (15%, 47/319) than in 2004 (33%, 181/556). Ceftriaxone resistance was detected in one isolate in 2007 and the percentage of *S.* Heidelberg isolates with intermediate susceptibility to ceftriaxone was significantly lower in 2007 (14%) than in 2004 (25%).

Table 3. Resistance to antimicrobials in *Salmonella* Heidelberg isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC n = 14	AB n = 40	SK n = 11	MB n = 24	ON n = 94	QC n = 63	NB n = 47	NS n = 17	PEI n = 5	NL n = 4	%
I	Amoxicillin-clavulanic acid	4 (29)	8 (20)	0 (0)	1 (4)	22 (23)	4 (6)	2 (4)	3 (18)	1 (20)	3 (75)	16
I	Ceftiofur	4 (29)	9 (23)	0 (0)	1 (4)	21 (22)	4 (6)	2 (4)	3 (18)	1 (20)	3 (75)	16
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (25)	<1
I	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
II	Ampicillin	6 (43)	12 (30)	4 (36)	2 (8)	33 (35)	23 (37)	5 (11)	6 (35)	2 (40)	3 (75)	32
II	Cefoxitin	4 (29)	8 (20)	0 (0)	1 (4)	21 (22)	4 (6)	2 (4)	3 (18)	1 (20)	3 (75)	16
II	Gentamicin	0 (0)	0 (0)	1 (9)	0 (0)	2 (2)	4 (6)	0 (0)	1 (6)	0 (0)	0 (0)	3
II	Kanamycin	0 (0)	1 (3)	1 (9)	0 (0)	2 (2)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	2
II	Nalidixic acid	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	Streptomycin	1 (7)	6 (15)	1 (9)	10 (42)	5 (5)	7 (11)	2 (4)	1 (6)	0 (0)	0 (0)	10
II	Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (4)	0 (0)	1 (20)	0 (0)	<1
III	Chloramphenicol	0 (0)	1 (3)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
III	Sulfisoxazole	0 (0)	1 (3)	1 (9)	8 (33)	2 (2)	4 (6)	0 (0)	1 (6)	0 (0)	0 (0)	5
III	Tetracycline	3 (21)	7 (18)	2 (18)	2 (8)	5 (5)	1 (2)	1 (2)	1 (6)	0 (0)	0 (0)	7
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentage for Canada corrected for non-proportional submission protocols among provinces (see Appendix A.2).

Salmonella Newport

(n = 127)

Provincial incidence rates of *Salmonella* Newport varied from 0 to 0.67 (median = 0.23) cases per 100,000 inhabitant-years. There were no reported cases in Newfoundland and Labrador or Prince Edward Island. The most common phage types were PT 9 (22%, 28/127), PT 2 (11%, 14/127), PT 3 (9%, 12/127), and PT 4 (7%, 9/127). Five percent (6/127) of isolates were cultured from urine. There were no isolates cultured from blood (Table B.1.2 in Appendix B).

[14] 2004 was selected as the year of comparison for results for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Antimicrobial Resistance: Results are presented in Table 4 and Table B.1.5 (Appendix B). Resistance to amoxicillin-clavulanic acid and to ceftiofur was detected in 3% (4/127) of *S.* Newport isolates. Two percent (2/127) were resistant to ceftriaxone, and another 2% had intermediate susceptibility. Reduced susceptibility to ciprofloxacin was detected in 3% (4/127) of isolates. Resistance to nalidixic acid was detected in 2% (2/127). None of the isolates were resistant to ciprofloxacin, amikacin, or gentamicin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 11% (14/127) of *S.* Newport isolates. Resistance to 5 or more antimicrobials was detected in 4% (5/127). The most common resistance pattern was sulfisoxazole alone (2%, 3/127). The following resistance patterns were detected in single isolates: ACSSuT (British Columbia, PT 14b), A2C-ACSSuT (Québec, PT 17c), A2C-ACSSuT-CRO (Québec, PT 14a), A2C-ACKSSuT-CRO-SXT (Québec, PT 17c), and A2C-ACKSSuT-SXT (Manitoba, PT 17c). Two isolates (PT 14b and PT 4) from British Columbia had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. Most urine isolates (4/6) were susceptible to all antimicrobials tested.

Temporal variations: Results are presented in Figure 2. The percentage of *S.* Newport isolates with the A2C-AMP resistance pattern was significantly lower in 2007 (3%, 4/127) than in 2003 (10%, 17/174). The percentage of isolates with resistance to ampicillin was also significantly lower in 2007 (5%), compared with percentage in 2003 (13%, 22/174). For the first time in Canada, the A2C-ACKSSuT-SXT resistance pattern was detected in an isolate (PT 17c), and that isolate originated from Manitoba. Prior to 2007, this resistance pattern had only been detected in 1 *S.* Typhimurium isolate tested through CIPARS in 2004.

In 2007, the resistance pattern A2C-ACKSSuT-SXT was detected in 1 of 127 human clinical isolates of *Salmonella* Newport. Prior to 2007, this resistance pattern had only been detected in 1 *S.* Typhimurium isolate tested through CIPARS in 2004. Another isolate had the A2C-ACSSuT- resistance pattern, 1 isolate had the A2C-ACSSuT-CRO resistance pattern, and 1 isolate had the A2C-ACKSSuT-CRO-SXT resistance pattern. However, the A2C-AMP resistance pattern was significantly less common in 2007 (3%, 4/127) than in 2003 (10%, 17/174).

Table 4. Resistance to antimicrobials in *Salmonella* Newport isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada
		BC n = 15	AB n = 11	SK n = 4	MB n = 7	ON n = 66	QC n = 18	NB n = 5	NS n = 1	PEI n = 0	NL n = 0	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			3
I	Ceftiofur	0 (0)	0 (0)	0 (0)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			3
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (11)	0 (0)	0 (0)			2
I	Ciprofloxacin	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
II	Ampicillin	1 (7)	0 (0)	1 (25)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			4
II	Cefoxitin	0 (0)	0 (0)	0 (0)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			3
II	Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)			0
II	Kanamycin	0 (0)	0 (0)	0 (0)	1 (14)	0 (0)	1 (6)	0 (0)	0 (0)			1
II	Nalidixic acid	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)			2
II	Streptomycin	1 (7)	0 (0)	1 (25)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			4
II	Trimethoprim-sulfamethoxazole	1 (7)	0 (0)	0 (0)	1 (14)	0 (0)	1 (6)	0 (0)	0 (0)			2
III	Chloramphenicol	2 (13)	0 (0)	0 (0)	1 (14)	0 (0)	3 (17)	0 (0)	0 (0)			5
III	Sulfisoxazole	1 (7)	0 (0)	2 (50)	1 (14)	3 (5)	3 (17)	0 (0)	0 (0)			7
III	Tetracycline	2 (13)	0 (0)	1 (25)	1 (14)	3 (5)	4 (22)	0 (0)	0 (0)			8
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate

No *Salmonella* Newport cases were reported in Prince Edward Island or Newfoundland and Labrador.

Salmonella Paratyphi A and Paratyphi B

(n = 45)

The combined provincial incidence rates of *Salmonella* Paratyphi A and *S.* Paratyphi B varied from 0 to 0.45 (median = 0) cases per 100,000 inhabitant-years. No cases were reported in New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador. *Salmonella* Paratyphi A isolate were not phage typed. Among all 6 isolates of *S.* Paratyphi B, phage types included 3b var 2 (1/6), Battersea (1/6), and Dundee (1/6). Fifty-one percent (20/39) of *S.* Paratyphi A isolates were cultured from blood, and 5% (2/39) were cultured from urine. No *S.* Paratyphi B isolates were cultured from blood or urine.

Antimicrobial Resistance: Results are presented in Table 5 and Table B.1.6 (Appendix B). Reduced susceptibility to ciprofloxacin and resistance to nalidixic acid was detected in 79% (31/39) of *S.* Paratyphi A isolates. None of the *S.* Paratyphi B isolates had reduced susceptibility to ciprofloxacin, resistance to nalidixic acid, or resistance to trimethoprim-sulfamethoxazole. None of the *S.* Paratyphi A or *S.* Paratyphi B isolates had intermediate susceptibility to ceftriaxone, and none were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, or kanamycin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 82% (32/39) of *S.* Paratyphi A isolates and in 1 of 6 *S.* Paratyphi B isolates. Resistance to 5 or more antimicrobials was detected in 3% (1/39) of *S.* Paratyphi A isolates and in 1 *S.* Paratyphi B isolate. The most common resistance pattern was nalidixic acid alone among *S.* Paratyphi A (79%, 31/39). One *S.* Paratyphi A isolate recovered from a blood sample had the ACSSuT-SXT resistance pattern, thirteen were resistant to nalidixic acid. Six *S.* Paratyphi A blood isolates were susceptible to all antimicrobials tested. One *S.* Paratyphi B isolate had the ACSSuT resistance pattern. Both *S.* Paratyphi A urine isolates were resistant to nalidixic acid.

Temporal variations: Results are presented in Figure 3. The percentages of *S.* Paratyphi A isolates resistant to nalidixic acid were similar in 2007 (79%, 31/39) and 2003 (73%, 19/26). However, the percentage of *S.* Paratyphi A isolates resistant to nalidixic acid in 2007 was significantly lower than in 2006 (93%, 55/59). Resistance to nalidixic acid was not detected among *S.* Paratyphi B isolates in 2007, but it was detected in 1 of 7 *S.* Paratyphi B isolates in 2006. Resistance to amoxicillin-clavulanic acid was not detected among *S.* Paratyphi A isolates in 2007, whereas it was detected in 8% (2/26) of *S.* Paratyphi A isolates recovered in 2003.

The percentage of human clinical isolates of *Salmonella* Paratyphi A that were resistant to nalidixic acid was significantly lower in 2007 (79%, 31/39) than in 2006 (93%, 55/59). Although 1 *S.* Paratyphi B isolate with resistance to nalidixic acid was identified in 2006, none were identified in 2007.

Table 5. Resistance to antimicrobials in *Salmonella* Paratyphi A and *S.* Paratyphi B isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC n = 10	AB n = 6	SK n = 1	MB n = 2	ON n = 20	QC n = 6	NB n = 0	NS n = 0	PEI n = 0	NL n = 0	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Ampicillin	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (17)					5
II	Cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Nalidixic acid	9 (90)	4 (67)	1 (100)	1 (50)	14 (70)	2 (33)					69
II	Streptomycin	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (17)					5
II	Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	0 (0)					2
III	Chloramphenicol	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (17)					5
III	Sulfisoxazole	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (17)					5
III	Tetracycline	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (17)					5
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentage for Canada corrected for non-proportional submission protocols among provinces (see Appendix A.2).

No *Salmonella* Paratyphi A or Paratyphi B cases were reported in New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador.

Salmonella Typhi

(n = 156)

Provincial incidence rates of *Salmonella* Typhi varied from 0 to 0.68 cases (median = 0) per 100,000 inhabitant-years. No cases were reported in Saskatchewan, New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador. The most common phage types recovered were PT E1 (45%, 70/156), PT G3 (10%, 16/156), PT E14 (9%, 14/156), and PT A (6%, 9/156). The phage type could not be identified in 7% (11/156) of isolates. Sixty-three percent (99/156) of isolates were cultured from blood, and 2 isolates were cultured from urine (Table B.1.2 in Appendix B).

Antimicrobial Resistance: Results are presented in Table 6 and Table B.1.7 (Appendix B). Resistance to ciprofloxacin was detected in 1% (2/156) of *S.* Typhi isolates. Reduced susceptibility to ciprofloxacin was detected in 77% (120/156). Resistance to nalidixic acid was detected in 78% (122/156) of isolates. None of the isolates had intermediate susceptibility to ceftriaxone, and none were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, amikacin, cefoxitin, gentamicin, or kanamycin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 81% (126/156) of *S.* Typhi isolates. Resistance to 5 or more antimicrobials was detected in 20% (32/156). The most common resistance pattern was nalidixic acid alone (55%, 86/156). The most common phage types resistant to nalidixic acid were PT E1 (57%, 49/86) and PT E14 (15%, 13/86). Two PT E1 isolates from Ontario had an ACSSuT resistance pattern. Fourteen isolates had the ACSSuT-NAL resistance pattern, including 8 isolates from Ontario (2 PT E1, 2 PT G3, 1 PT UVS [I+IV]), and 3 untypable), 3 isolates from Alberta (1 PT G3, 1 PT UVS [I+IV], and 1 untypable), 1 PT E1 isolate from British Columbia, 1 PT E1 isolate from Manitoba, and 1 untypable isolate from Québec. Three isolates had reduced susceptibility or resistance to ciprofloxacin but were not resistant to nalidixic acid. Seventeen percent (17/99) of blood and both urine isolates were susceptible to all antimicrobials tested. Fifty-seven percent (56/99) of blood isolates had resistance to nalidixic acid alone, 12% (12/99) had the ACSSuT-NAL resistance pattern, and 1% (1/99) had the ACSSuT resistance pattern.

Temporal variations: Results are presented in Figure 3. The percentage of *S.* Typhi isolates that were resistant to nalidixic acid was significantly higher in 2007 (78%) than in 2003 (44%, 56/127). The percentage of isolates resistant to ampicillin, chloramphenicol, or streptomycin was significantly higher in 2007 (21%, 32/156) than in 2003 (10%, 13/127). In addition, the percentage of isolates resistant to sulfisoxazole was significantly higher in 2007 (23%, 36/156) than in 2003 (9%, 12/127), as was the percentage of isolates resistant to trimethoprim-sulfamethoxazole (2007: 21% [32/156], 2003: 9% [12/127]). New resistance patterns detected in 2007 included NAL-SSS, CIP-NAL, and AMP-NAL-STR-SSS-TET.

The percentage of human clinical isolates of *Salmonella* Typhi that were resistant to nalidixic acid continues to be of concern because the percentage was significantly higher in 2007 (78%, 122/157) than in 2003 (44%, 56/127). The percentage of isolates with resistance to ampicillin, chloramphenicol, streptomycin, sulfisoxazole, or trimethoprim-sulfamethoxazole was also significantly higher in 2007 (21%) than in 2003 (9%).

Table 6. Resistance to antimicrobials in *Salmonella* Typhi isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada
		BC n = 26	AB n = 20	SK n = 0	MB n = 4	ON n = 87	QC n = 19	NB n = 0	NS n = 0	PEI n = 0	NL n = 0	%
I	Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
I	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)					1
II	Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Ampicillin	1 (4)	5 (25)	0 (0)	3 (75)	19 (22)	4 (21)					20
II	Cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)					0
II	Nalidixic acid	25 (96)	15 (75)	0 (0)	4 (100)	68 (78)	10 (53)					78
II	Streptomycin	1 (4)	5 (25)	0 (0)	3 (75)	19 (22)	4 (21)					20
II	Trimethoprim-sulfamethoxazole	1 (4)	7 (35)	0 (0)	3 (75)	17 (20)	4 (21)					20
III	Chloramphenicol	1 (4)	7 (35)	0 (0)	3 (75)	17 (20)	4 (21)					20
III	Sulfisoxazole	2 (8)	7 (35)	0 (0)	3 (75)	20 (23)	4 (21)					22
III	Tetracycline	2 (8)	3 (15)	0 (0)	1 (25)	13 (15)	1 (5)					13
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.
No *Salmonella* Typhi cases were reported in Saskatchewan, New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland and Labrador.

Salmonella Typhimurium
(n = 658)

Provincial incidence rates of *Salmonella* Typhimurium varied from 0.59 to 5.68 (median = 2.08) cases per 100,000 inhabitant-years. The most common phage types recovered were PT 108 (32%, 214/658), PT 104 (9%, 59/658), PT 3 aerogenic (5%, 32/658), and PT atypical (4%, 29/658). Three percent (17/658) of isolates were cultured from blood, and 2% (14/658) were cultured from urine (Table B.1.2 in Appendix B).

Antimicrobial Resistance: Results are presented in Table 7 and Table B.1.8 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 2% (12/658) of *S.* Typhimurium isolates. Resistance to ceftiofur was detected in 1% (9/658) of isolates. One isolate was resistant to ceftriaxone, and 1% (7/658) of isolates had intermediate susceptibility to ceftriaxone. Less than 1% (3/658) of isolates were resistant to ciprofloxacin, and 5% (33/658) had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 3% (23/658) of isolates. None of the isolates were resistant to amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 34% (222/658) of *S.* Typhimurium isolates. Resistance to 5 or more antimicrobials was detected in 17% (111/658). The most common resistance pattern was ACSSuT (10%, 68/658) and most isolates with this pattern were PT 104 (53%, 37/68). The ACSSuT resistance pattern was detected in combination with resistance to other antimicrobials in 2% (11/658) of isolates. The A2C-ACSSuT resistance pattern was detected in 4 isolates, and the same resistance pattern was detected in combination with the GEN-NAL-SXT resistance pattern in 1 isolate or with additional resistance to trimethoprim-sulfamethoxazole in another isolate. The ACKSSuT resistance pattern alone was detected in 1% (7/658) of isolates, and the same resistance pattern was detected in combination with resistance pattern AMC-SXT or in combination with resistance to trimethoprim-sulfamethoxazole in less than 1% (5/658). The AKSSuT resistance pattern alone was detected in 5 isolates, and the same resistance pattern was detected in combination with other resistance patterns (GEN-SXT or GEN-NAL-SXT) in 2 other isolates. Three isolates had the A2C-AMP resistance pattern with the additional resistance pattern CRO-CHL-STR-TET-SXT, KAN-SSS-TET, or SSS-SXT. One isolate (PT 104b) had resistance to nalidixic acid and intermediate susceptibility to ceftriaxone. Three percent (17/658) of isolates had reduced susceptibility to ciprofloxacin but were not resistant to nalidixic acid. Most blood isolates (12/17) and urine isolates (9/14) were not resistant to any antimicrobials tested. One blood isolate (PT 104a) had an ACSSuT resistance pattern.

Temporal variations: Results are presented in Figure 3. The percentage of *S.* Typhimurium isolates with resistance to nalidixic acid was significantly higher in 2007 (3%) than in 2003 (1%, 7/610). The percentage of isolates with the ACSSuT resistance pattern, alone or with resistance to additional antimicrobials, was also significantly lower in 2007 (12%, 79/658) than in 2003 (23%, 141/610). This decrease could have been attributable to the lower percentage of PT 104 isolates among all isolates with the ACSSuT resistance pattern in 2007 (6%, 37/658) versus 2003 (18%, 109/610). The percentage of PT 104 isolates with the ACSSuT resistance pattern was also significantly lower in 2007 (63%, 37/59) than in 2003 (74%, 109/147). New resistance patterns detected in 2007 included A2C-AMP-SSS-SXT, A2C-AMP-KAN-SSS-TET, A2C-AMP-CRO-CHL-STR-TET-SXT, ACSSuT-GEN, ACSSuT-A2C-GEN-NAL-SXT, and AKSSuT-GEN-NAL-SXT.

The percentage of human clinical isolates of *Salmonella* Typhimurium with the ACSSuT resistance pattern in 2007 (10%, 68/658) was significantly lower than that in 2003 (21%, 127/610). This decrease was likely attributable to the lower percentage of PT 104 isolates among all isolates with the same resistance pattern in 2007 (6%) versus 2003 (18%). On the other hand, the percentage of isolates with resistance to nalidixic acid was significantly higher in 2007 (3%) than in 2003 (1%).

Table 7. Resistance to antimicrobials in *Salmonella* Typhimurium isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
		n = 46	n = 62	n = 25	n = 26	n = 365	n = 101	n = 15	n = 10	n = 5	n = 3	%
I	Amoxicillin-clavulanic acid	2 (4)	1 (2)	0 (0)	1 (4)	1 (0)	5 (5)	0 (0)	1 (10)	0 (0)	1 (33)	2
I	Ceftiofur	1 (2)	1 (2)	0 (0)	1 (4)	0 (0)	5 (5)	0 (0)	0 (0)	0 (0)	1 (33)	1
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
I	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	1 (10)	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
II	Ampicillin	19 (41)	19 (31)	6 (24)	7 (27)	61 (17)	27 (27)	2 (13)	3 (30)	0 (0)	1 (33)	22
II	Cefoxitin	1 (2)	1 (2)	0 (0)	1 (4)	0 (0)	5 (5)	0 (0)	0 (0)	0 (0)	1 (33)	1
II	Gentamicin	2 (4)	1 (2)	0 (0)	0 (0)	5 (1)	2 (2)	0 (0)	1 (10)	0 (0)	0 (0)	2
II	Kanamycin	4 (9)	15 (24)	1 (4)	4 (15)	6 (2)	14 (14)	3 (20)	1 (10)	0 (0)	0 (0)	7
II	Nalidixic acid	6 (13)	2 (3)	1 (4)	0 (0)	9 (2)	3 (3)	0 (0)	2 (20)	0 (0)	0 (0)	3
II	Streptomycin	21 (46)	30 (48)	6 (24)	5 (19)	59 (16)	23 (23)	2 (13)	3 (30)	0 (0)	0 (0)	23
II	Trimethoprim-sulfamethoxazole	4 (9)	1 (2)	1 (4)	1 (4)	13 (4)	9 (9)	1 (7)	1 (10)	0 (0)	1 (33)	5
III	Chloramphenicol	18 (39)	12 (19)	5 (20)	2 (8)	47 (13)	18 (18)	1 (7)	3 (30)	0 (0)	0 (0)	16
III	Sulfisoxazole	22 (48)	30 (48)	6 (24)	8 (31)	68 (19)	37 (37)	4 (27)	5 (50)	0 (0)	1 (33)	27
III	Tetracycline	22 (48)	21 (34)	5 (20)	10 (38)	70 (19)	39 (39)	6 (40)	3 (30)	0 (0)	0 (0)	27
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentage for Canada corrected for non-proportional submission protocols among provinces (see Appendix A.2).

Salmonella "Other Serovars"
(n = 1,093)

In 2007, "Other Serovars" represented 33% of all *Salmonella* isolates and included 142 different serovars. Two percent (26/1,093) of isolates were cultured from blood, and 5% (52/1,093) were cultured from urine (Table B.1.2 in Appendix B).

Antimicrobial Resistance: Results are presented in Table 8 and Table B.1.9 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 1% (11/1,093) of the "Other Serovars" isolates (Agona, Hadar, ssp. I 4,[5],12:i:-, Infantis, and Saintpaul). Resistance to ceftiofur was detected in less than 1% (8/1,093) of isolates (Agona, ssp. I 4,[5],12:i:-, Infantis, and Saintpaul). Less than 1% (2/1,093) of isolates (ssp. I 4,[5],12:i:- and Saintpaul) were resistant to ceftriaxone, and less than 1% (6/1,093; Agona, ssp. I 4,[5],12:i:-, and Infantis) had intermediate susceptibility to ceftriaxone. Less than 1% (3/1,093) of isolates (Blockley and Kentucky) were resistant to ciprofloxacin, and 5% (52/1,093) had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 3% (36/1,093), which included 6/13 Virchow isolates. None of the isolates were resistant to amikacin.

Antimicrobial Resistance Patterns: Results are presented in Table 9. Resistance to 1 or more antimicrobials was detected in 22% (246/1,093) of *Salmonella* "Other Serovars" isolates. This included 95% (73/77) of Hadar isolates. Resistance to 5 or more antimicrobials was detected in 2% (27/1,093) of isolates. The most common resistance pattern was tetracycline alone (6%, 64/1,093) and was detected primarily in Mbandaka (50%, 19/38), Hadar (22%, 17/77), and Saintpaul (9%, 5/58) isolates. The resistance pattern STR-TET was detected in 4% (42/1,093) of all isolates, of which 86% (36/42) were Hadar. The A2C-AMP resistance pattern alone was detected in 4 isolates (ssp. I 4,[5],12:i:- and Infantis) and with other resistance patterns (ceftriaxone, SSS-SXT, or SSS-TET) in 4 isolates (Agona and ssp. I 4,[5],12:i:-). The ACKSSuT resistance pattern was detected alone in 1 Stanley isolate and with another resistance pattern (GEN-NAL-SXT) in 1 Choleraesuis isolate. Three isolates (Paratyphi B var. L[+] and Saintpaul) had the ACSSuT resistance pattern and 2 isolates (ssp. I 4,[5],12:i:- and Meleagridis) had the AKSSuT resistance pattern. Two percent (20/1,093) of the isolates (Braenderup, Corvallis, Hadar, ssp. I 4,[5],12:b:-, ssp. I 4,[5],12:i:-, Kentucky, Larochelle, Litchfield, Montevideo, Muenster, Nima, Oranienburg, Reading, Saintpaul, Schwarzengrund, and Tambacounda) had reduced susceptibility to ciprofloxacin and were not resistant to nalidixic acid. Most blood (73%, 19/26) and urine (85%, 44/52) isolates were susceptible to all antimicrobials tested. One urine isolate (Infantis) had the A2C-AMP resistance pattern.

Temporal variations: Results are presented in Figure 3. In 2007, 31 new *Salmonella* serovars were identified, consisting of a total of 34 isolates, of which 1 isolate (I 6,7:c:-) had the AMP-CHL-GEN-NAL-SSS-TET-SXT resistance pattern. The percentage of "Other Serovars" with resistance to gentamicin was significantly lower in 2007 (less than 1%) than in 2003 (2%, 21/1,151). The percentage of isolates with resistance to chloramphenicol was also significantly lower in 2007 (2%, 18/1,093) than in 2003 (3%, 38/1,151). The following resistance patterns were identified in the indicated serovars for the first time in 2007: 1 ssp. I 4,[5],12:i:- isolate with an A2C-AMP-CRO pattern, 1 ssp. I 4,[5],12:i:- isolate with an A2C-AMP-SSS-SXT pattern, 1 ssp. I 4,[5],12:i:- isolate with an AKSSuT pattern, 1 Meleagridis isolate with an AKSSuT pattern, 1 Saintpaul isolate with an A2C-AMP-CRO pattern, and 2 Saintpaul isolates with an ACSSuT resistance pattern.

Of the 2007 results for antimicrobial resistance in human clinical isolates of *Salmonella* "Other Serovars," it is notable that there was a high proportion of *S.* Virchow isolates (6/13) with resistance to nalidixic acid and a high percentage (95%, 73/77) of *S.* Hadar isolates with resistance to 1 or more antimicrobials.

Table 8. Resistance to antimicrobials in *Salmonella* "Other Serovars" isolates from humans, by province; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	Number (%) of isolates resistant										Canada[a]
		BC n = 127	AB n = 120	SK n = 41	MB n = 92	ON n = 510	QC n = 131	NB n = 24	NS n = 25	PEI n = 2	NL n = 21	%
I	Amoxicillin-clavulanic acid	1 (1)	1 (1)	0 (0)	0 (0)	6 (1)	2 (2)	0 (0)	1 (4)	0 (0)	0 (0)	1
I	Ceftiofur	0 (0)	1 (1)	0 (0)	0 (0)	4 (1)	2 (2)	0 (0)	1 (4)	0 (0)	0 (0)	< 1
I	Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
I	Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	3 (1)	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
II	Ampicillin	6 (5)	7 (6)	2 (5)	6 (7)	28 (5)	8 (6)	2 (8)	2 (8)	0 (0)	0 (0)	6
II	Cefoxitin	0 (0)	1 (1)	0 (0)	0 (0)	4 (1)	2 (2)	0 (0)	1 (4)	0 (0)	0 (0)	< 1
II	Gentamicin	1 (1)	1 (1)	1 (2)	0 (0)	2 (0)	0 (0)	1 (4)	0 (0)	0 (0)	0 (0)	< 1
II	Kanamycin	2 (2)	2 (2)	2 (5)	3 (3)	4 (1)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1
II	Nalidixic acid	5 (4)	4 (3)	1 (2)	3 (3)	15 (3)	2 (2)	3 (13)	1 (4)	0 (0)	2 (10)	3
II	Streptomycin	13 (10)	20 (17)	5 (12)	12 (13)	43 (8)	11 (8)	2 (8)	1 (4)	0 (0)	5 (24)	10
II	Trimethoprim-sulfamethoxazole	6 (5)	4 (3)	1 (2)	4 (4)	15 (3)	1 (1)	2 (8)	0 (0)	0 (0)	0 (0)	3
III	Chloramphenicol	5 (4)	2 (2)	2 (5)	4 (4)	2 (0)	0 (0)	1 (4)	1 (4)	0 (0)	1 (5)	1
III	Sulfisoxazole	13 (10)	15 (13)	4 (10)	11 (12)	31 (6)	5 (4)	3 (13)	2 (8)	0 (0)	1 (5)	8
III	Tetracycline	26 (20)	25 (21)	5 (12)	37 (40)	76 (15)	18 (14)	5 (21)	3 (12)	0 (0)	6 (29)	17
IV												

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

[a] Estimated percentage for Canada corrected for non-proportional submission protocols among provinces (see Appendix A.2).

Table 9. Number of antimicrobials in resistance patterns of *Salmonella* isolates from humans, by province and serovar; *Surveillance of Human Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
British Columbia					
Enteritidis	144 (37.7)	116	26	2	0
Typhimurium	46 (12)	18	10	17	1
Typhi	26 (6.8)	1	24	1	0
I 4,[5],12:i:-	15 (3.9)	12	2	1	0
Newport	15 (3.9)	13	1	1	0
Heidelberg	14 (3.7)	5	8	1	0
Oranienburg	9 (2.4)	9	0	0	0
Paratyphi A	9 (2.4)	0	9	0	0
Stanley	8 (2.1)	6	1	1	0
Less common serovars	96 (25.1)	72	22	2	0
Total	382 (100)	252	103	26	1
Alberta					
Enteritidis	138 (34.8)	110	27	1	0
Typhimurium	62 (15.6)	27	23	12	0
Heidelberg	40 (10.1)	22	17	1	0
Typhi	20 (5)	3	12	5	0
I 4,[5],12:i:-	17 (4.3)	11	5	1	0
Oranienburg	15 (3.8)	15	0	0	0
Hadar	13 (3.3)	2	11	0	0
Newport	11 (2.8)	11	0	0	0
Less common serovars	81 (20.4)	60	20	1	0
Total	397 (100)	261	115	21	0
Saskatchewan					
Enteritidis	38 (31.7)	33	4	1	0
Typhimurium	25 (20.8)	17	3	5	0
Heidelberg	11 (9.2)	5	6	0	0
I 4,[5],12:i:-	8 (6.7)	7	1	0	0
Paratyphi B var. L(+)	7 (5.8)	6	1	0	0
Saintpaul	5 (4.2)	5	0	0	0
Newport	4 (3.3)	2	2	0	0
Infantis	3 (2.5)	3	0	0	0
Virchow	3 (2.5)	3	0	0	0
Less common serovars	16 (13.3)	11	4	0	1
Total	120 (100)	92	21	6	1
Manitoba					
Enteritidis	53 (25.5)	46	7	0	0
Typhimurium	26 (12.5)	14	8	4	0
Heidelberg	24 (11.5)	13	10	1	0
Mbandaka	24 (11.5)	2	22	0	0
Give	7 (3.4)	7	0	0	0
Newport	7 (3.4)	6	0	0	1
Saintpaul	7 (3.4)	4	0	3	0
Hadar	5 (2.4)	0	5	0	0
Less common serovars	55 (26.4)	39	11	5	0
Total	208 (100)	131	63	13	1
Ontario					
Typhimurium	365 (24.6)	284	35	44	2
Enteritidis	340 (22.9)	275	64	1	0
Heidelberg	94 (6.3)	55	39	0	0
Typhi	87 (5.9)	17	51	19	0
Newport	66 (4.5)	61	5	0	0
Thompson	61 (4.1)	61	0	0	0
Oranienburg	45 (3)	44	1	0	0
Infantis	35 (2.4)	31	4	0	0
Hadar	33 (2.2)	0	32	1	0
Less common serovars	356 (24)	282	66	8	0
Total	1482 (100)	1110	297	73	2

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Table 9 (continued). Number of antimicrobials in resistance patterns of *Salmonella* isolates from humans, by province and serovar; *Surveillance of Human Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern 0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Québec					
Enteritidis	113 (25.1)	86	25	2	0
Typhimurium	101 (22.4)	57	23	19	2
Heidelberg	63 (14)	37	26	0	0
Typhi	19 (4.2)	9	6	4	0
Newport	18 (4)	14	1	1	2
Saintpaul	15 (3.3)	14	0	1	0
Hadar	12 (2.7)	1	11	0	0
I 4,[5],12:i:-	12 (2.7)	9	2	1	0
Infantis	10 (2.2)	9	1	0	0
Thompson	10 (2.2)	10	0	0	0
Less common serovars	78 (17.3)	70	6	2	0
Total	451 (100)	316	101	30	4
New Brunswick					
Heidelberg	47 (36.2)	41	6	0	0
Enteritidis	39 (30)	29	10	0	0
Typhimurium	15 (11.5)	8	6	1	0
Newport	5 (3.8)	5	0	0	0
Saintpaul	4 (3.1)	3	1	0	0
Thompson	4 (3.1)	3	1	0	0
Less common serovars	16 (12.3)	11	3	2	0
Total	130 (100)	100	27	3	0
Nova Scotia					
Enteritidis	32 (37.6)	20	12	0	0
Heidelberg	17 (20)	11	5	1	0
Typhimurium	10 (11.8)	4	3	2	1
Thompson	8 (9.4)	8	0	0	0
Agona	3 (3.5)	2	0	1	0
I 4,[5],12:i:-	2 (2.4)	2	0	0	0
Less common serovars	13 (15.3)	10	2	1	0
Total	85 (100)	57	22	5	1
Prince Edward Island					
Enteritidis	5 (29.4)	3	2	0	0
Heidelberg	5 (29.4)	3	2	0	0
Typhimurium	5 (29.4)	5	0	0	0
Infantis	2 (11.8)	2	0	0	0
Total	17 (100)	13	4	0	0
Newfoundland and Labrador					
Enteritidis	8 (22.2)	7	1	0	0
Hadar	5 (13.9)	0	5	0	0
Heidelberg	4 (11.1)	1	2	1	0
Saintpaul	3 (8.3)	2	1	0	0
Typhimurium	3 (8.3)	2	0	1	0
I 4,[5],12:i:-	2 (5.6)	1	1	0	0
Oranienburg	2 (5.6)	2	0	0	0
Thompson	2 (5.6)	2	0	0	0
Agona	1 (2.8)	1	0	0	0
I 4,[5],12:d:-	1 (2.8)	1	0	0	0
I Rough-O:-:-	1 (2.8)	1	0	0	0
Infantis	1 (2.8)	1	0	0	0
Inverness	1 (2.8)	1	0	0	0
Montevideo	1 (2.8)	1	0	0	0
Schwarzengrund	1 (2.8)	1	0	0	0
Total	36 (100)	24	10	2	0
Total	**3308 (100)**	**2356**	**763**	**179**	**10**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Figure 2. Temporal variation in resistance to selected antimicrobials in human isolates of *Salmonella* serovars Enteritidis, Heidelberg, and Newport; *Surveillance of Human Clinical Isolates*, 2003–2007.

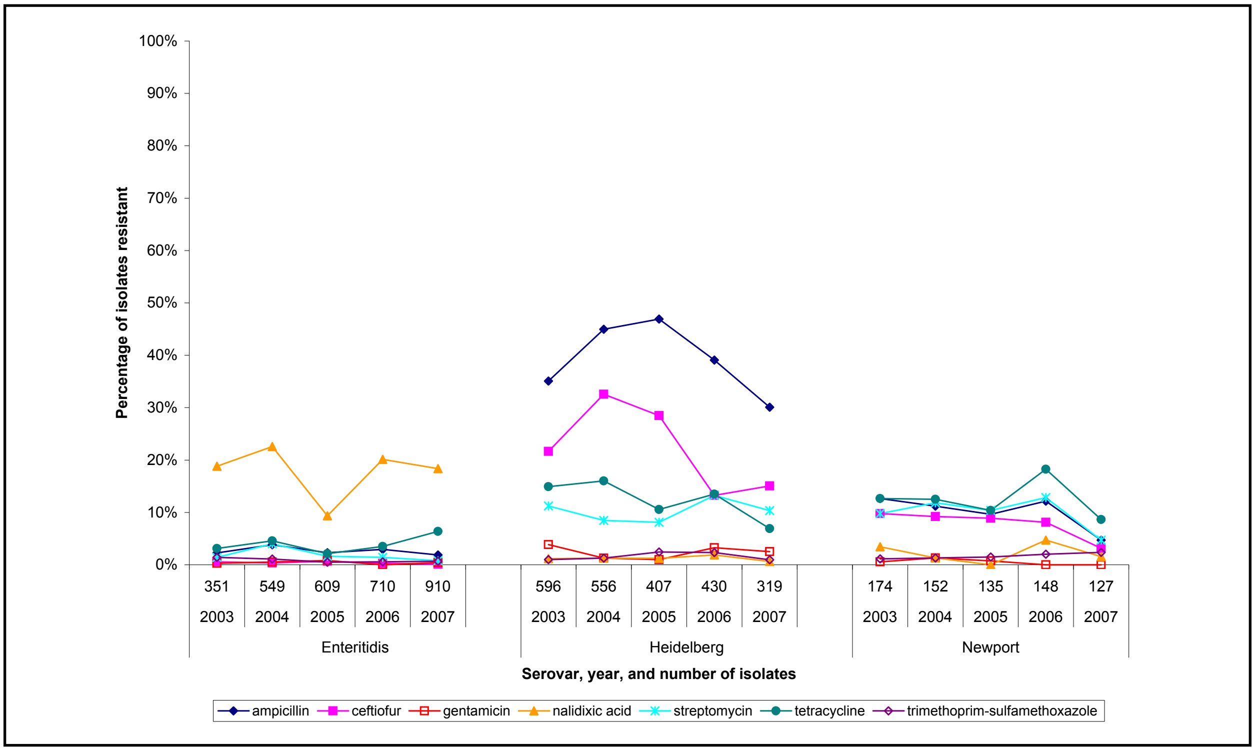
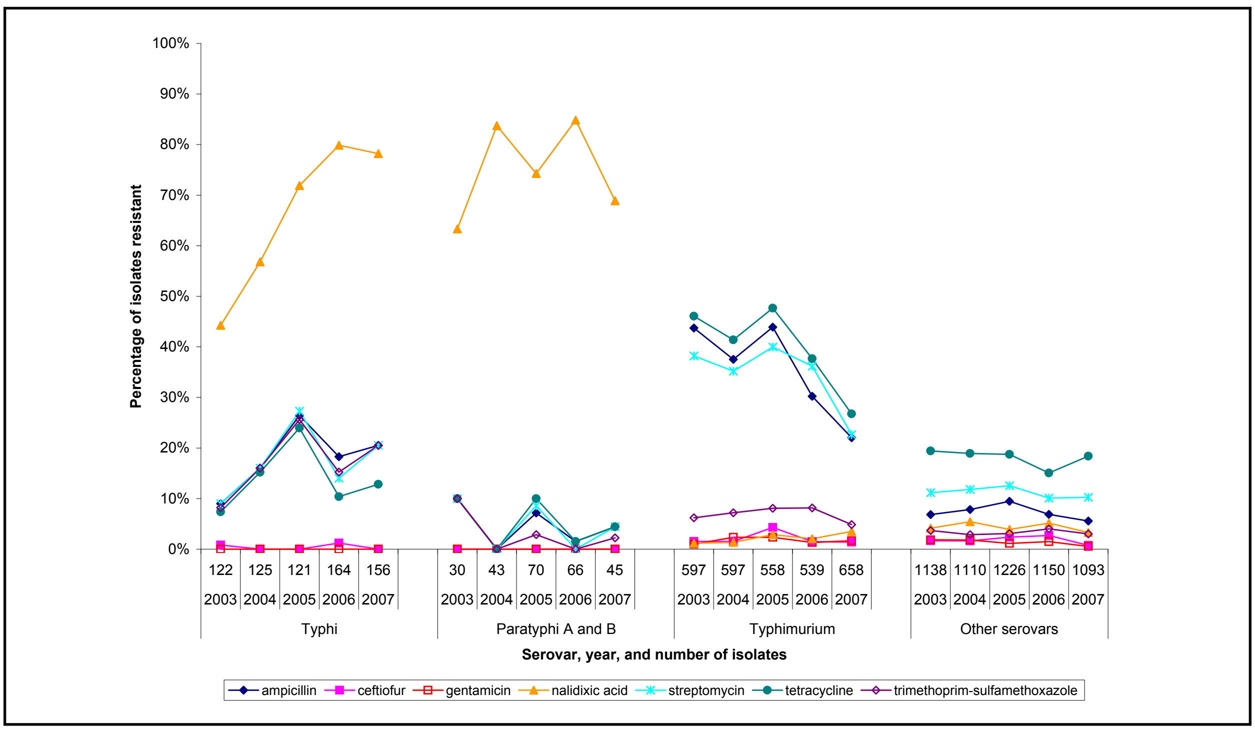


Figure 3. Temporal variation in resistance to selected antimicrobials in human isolates of *Salmonella* serovars Paratyphi A and B, Typhi, Typhimurium, and "Other Serovars"; *Surveillance of Human Clinical Isolates*, 2003–2007.



Beef Cattle

Salmonella

Surveillance of Animal Clinical Isolates

(n = 140)

Note: These cattle may have included both dairy and beef cattle.

Serovars: Results are presented in Table 10. The most common *Salmonella* serovars were Typhimurium (25%, 35/140), Kentucky (21%, 29/140), and Cerro (9%, 13/140). These 3 serovars accounted for 55% (77/140) of the isolates.

Antimicrobial Resistance: Results are presented in Table B.2.1 (Appendix B). Resistance to amoxicillin-clavulanic acid and ceftiofur was detected in 2% (3/140) of the isolates. None of the isolates were resistant to ceftriaxone, ciprofloxacin, or nalidixic acid. Additionally, 1% (2/140) of the isolates had intermediate susceptibility to ceftriaxone. None of the isolates had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 10. Resistance to 1 or more antimicrobials was detected in 25% (35/140) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 16% (22/140). The most common resistance patterns were ACKSSuT (6%, 9/140) and ACSSuT (5%, 7/140).

Forty percent (14/35) of *S.* Typhimurium isolates were resistant to 5 or more antimicrobials. Seven percent (10/140), 5% (7/140), 1% (2/140), and 1 *Salmonella* isolate had the ACKSSuT, ACSSuT, A2C-ACKSSuT, and A2C-ACSSuT resistance patterns, respectively. The resistance pattern involving the most antimicrobials was ACKSSuT-A2C-SXT, which was detected in 2 *S.* Typhimurium var. 5- isolates.

In 2007, the ACKSSuT, ACSSuT, A2C-ACKSSuT, and A2C-ACSSuT resistance patterns were detected in 14% (20/140) of clinical cattle isolates of *Salmonella*.

Table 10. Number of antimicrobials in resistance patterns of *Salmonella* isolates from cattle, by serovar; *Surveillance of Animal Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	35 (25)	19	2	14	0
Kentucky	29 (20.7)	28	1	0	0
Cerro	13 (9.3)	12	1	0	0
Typhimurium var. 5-	12 (8.6)	0	4	6	2
I:6,14,18:-:-	11 (7.9)	11	0	0	0
Thompson	6 (4.3)	6	0	0	0
I:4,12:i:-	4 (2.9)	3	1	0	0
Schwarzengrund	4 (2.9)	4	0	0	0
Anatum	3 (2.1)	0	3	0	0
Infantis	3 (2.1)	3	0	0	0
Montevideo	3 (2.1)	3	0	0	0
Less common serovars	17 (12.1)	16	1	0	0
Total	**140 (100)**	**105**	**13**	**20**	**2**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Escherichia Coli

Abattoir Surveillance
(n = 188)

Recovery: *Escherichia coli* isolates were recovered from 99% (188/190) of all beef cattle cecal samples (Table B.4.3 in Appendix B).

Antimicrobial Resistance: Results are presented in Figure 4 and Table B.2.2 (Appendix B). None of the *E. coli* isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, nalidixic acid, or trimethoprim-sulfamethoxazole. Additionally, none of the isolates had intermediate susceptibility to ceftriaxone or reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 41% (77/188) of the isolates. None of the isolates were resistant to 5 or more antimicrobials. The most common resistance patterns were tetracycline alone (15%, 29/188) and SSS-TET (6%, 12/188).

Temporal variations: Results are presented in Figure 5. Between 2003 and 2007, there were no significant temporal variations in percentages of *E. coli* isolates resistant to selected antimicrobials.

In 2007, resistance to 1 or more antimicrobials was detected in 41% (77/188) of *Escherichia coli* isolates from abattoir beef cattle. The most common resistance patterns were tetracycline alone (15%, 29/188) and SSS-TET (6%, 12/188). None of the isolates were resistant to 5 or more antimicrobials.

Figure 4. Resistance to antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2007.

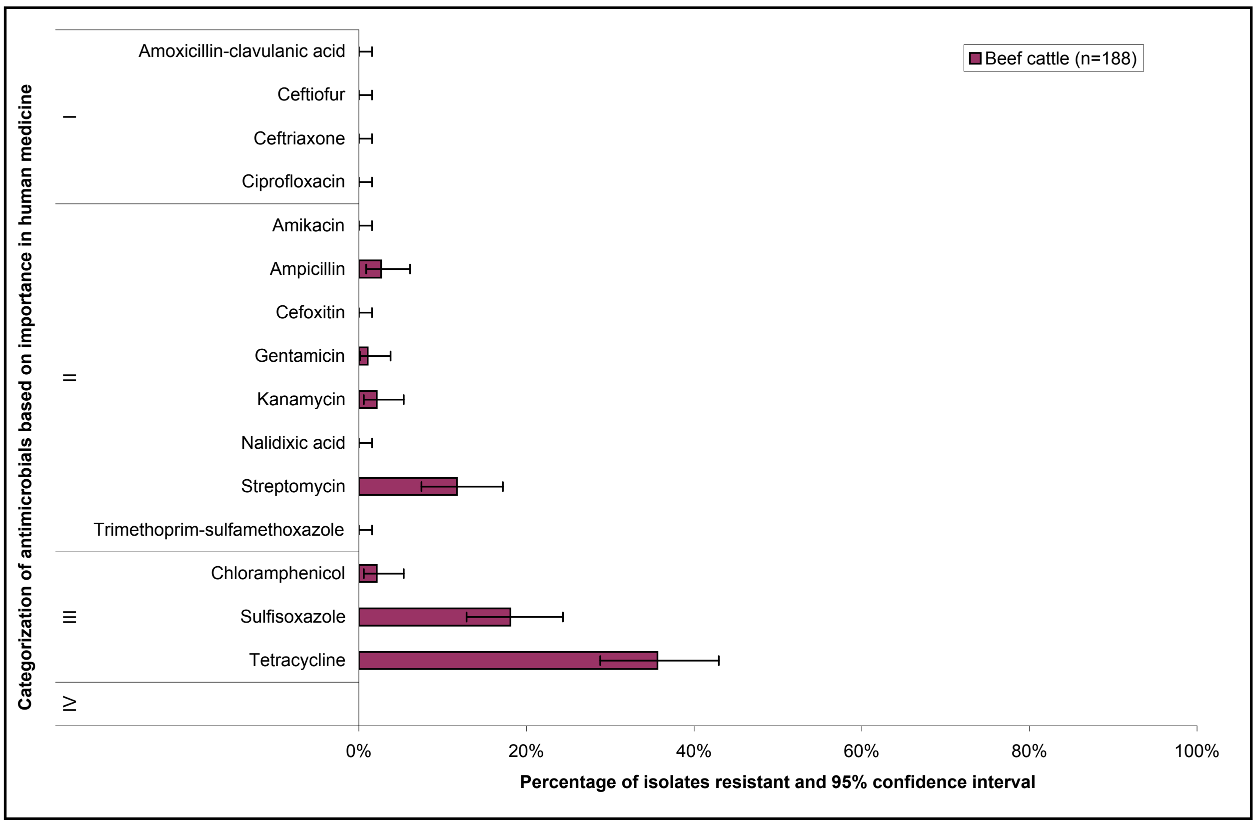
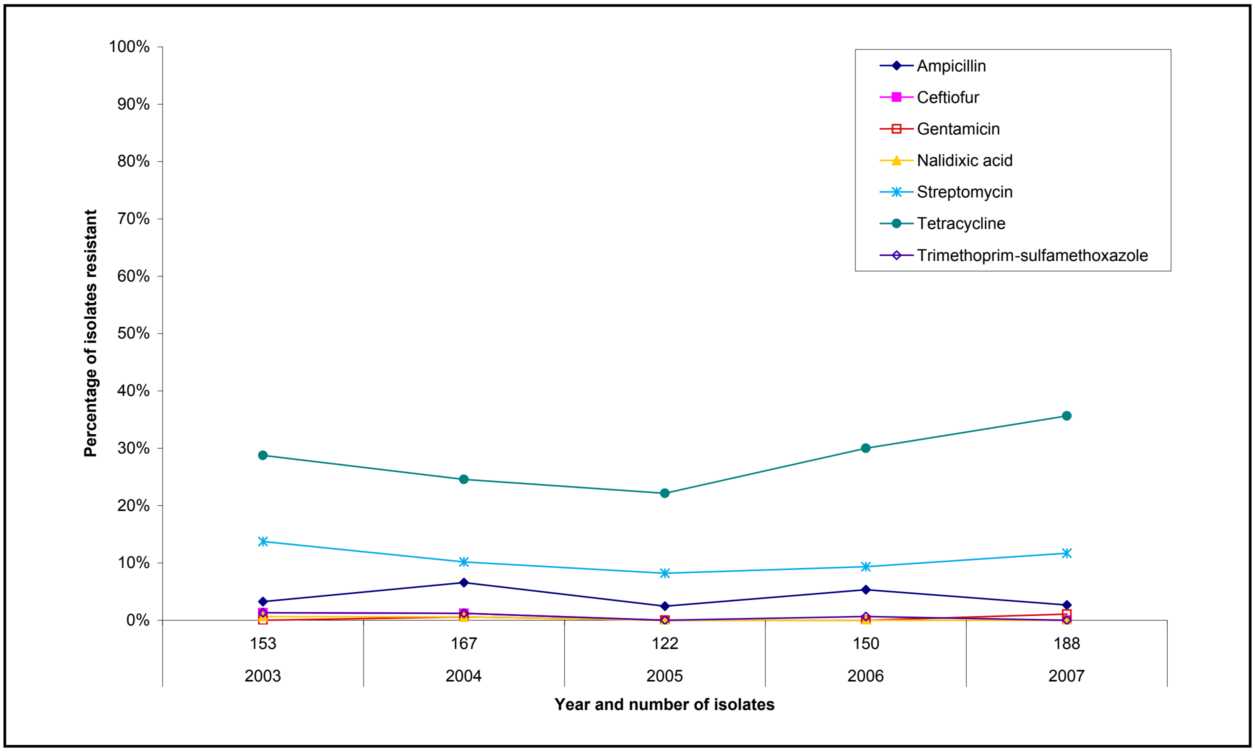


Figure 5. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2003–2007.



Retail Meat Surveillance

(n = 501)

(British Columbia, n = 49; Saskatchewan, n = 118; Ontario, n = 187; Québec, n = 147)

Recovery: *Escherichia coli* isolates were recovered from 75% (501/671) of all retail beef samples. Province-specific percentages of beef samples from which *Escherichia coli* isolates were recovered were as follows: British Columbia, 79% (49/62); Saskatchewan, 78% (118/151); Ontario, 77% (187/242); and Québec, 68% (147/216; Table B.4.3 in Appendix B).

Antimicrobial Resistance: Results are presented in Figure 6 and Table B.2.3 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 1 *E. coli* isolate from Saskatchewan and 1 isolate from Québec. Resistance to ceftiofur was detected in 1 isolate from Québec. None of the isolates had intermediate susceptibility to ceftriaxone but 2 had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 1 isolate from British Columbia and 1 isolate from Ontario. There were no significant differences among the provinces in percentages of isolates with resistance to any of the antimicrobials tested. None of the isolates from any province were resistant to ceftriaxone, ciprofloxacin, or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 12% (6/49) of *E. coli* isolates from British Columbia, 8% (10/118) of isolates from Saskatchewan, 14% (27/187) of isolates from Ontario, and 18% (26/147) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 1 isolate from British Columbia, 1 isolate from Saskatchewan, 2% (4/187) of isolates from Ontario, and 3% (4/147) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were tetracycline alone (5%, 23/501) and SSS-TET (3%, 15/501). The ACSSuT pattern was detected in 2 isolates, the AKSSuT pattern was detected in 1 isolate, and the ACKSSuT pattern was detected in 1 isolate.

Temporal variations: Results are presented in Figure 7. The percentage of *E. coli* isolates from Ontario with streptomycin resistance was significantly lower in 2007 (3%, 6/187) than in 2003 (11%, 11/101). In other provinces, there were no significant temporal variations in the percentages of *E. coli* isolates resistant to selected antimicrobials.

In 2007, few of the 501 *Escherichia coli* isolates from retail beef were resistant to the Category I antimicrobials. Only 1 isolate (from Québec) was resistant to ceftiofur, and 2 isolates (1 from Saskatchewan and 1 from Québec) were resistant to amoxicillin-clavulanic acid. Resistance to nalidixic acid was detected in 1 isolate from British Columbia and another from Ontario.

Figure 6. Resistance to antimicrobials in *Escherichia coli* isolates from beef; *Retail Meat Surveillance*, 2007.

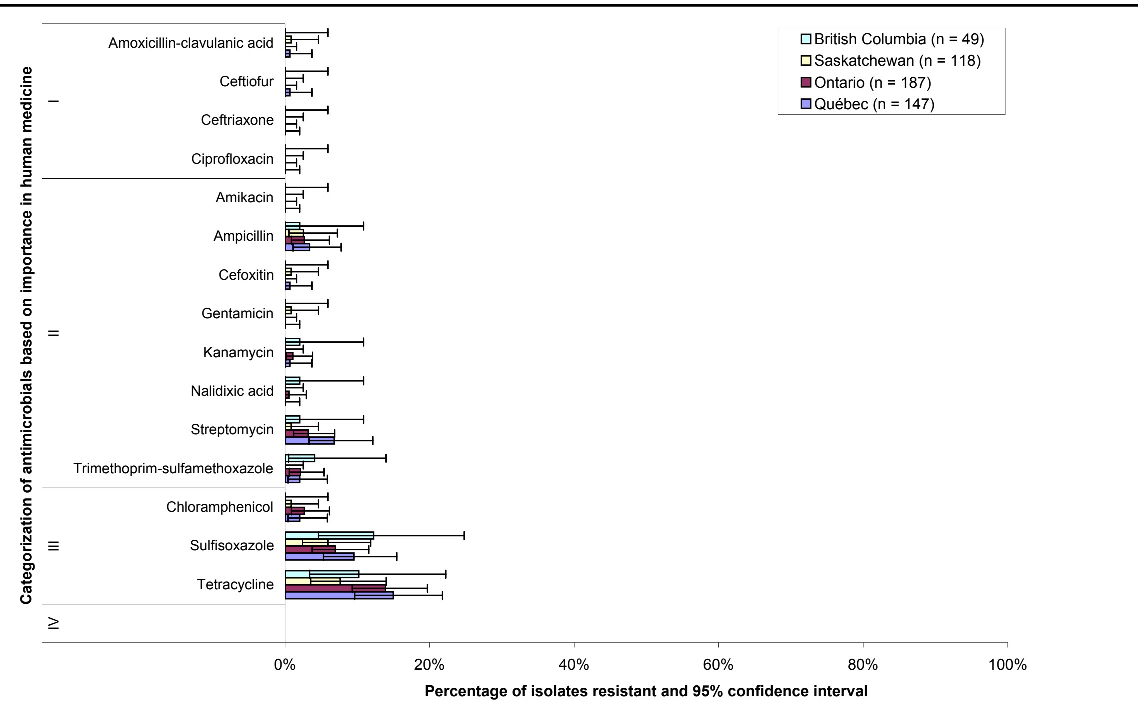
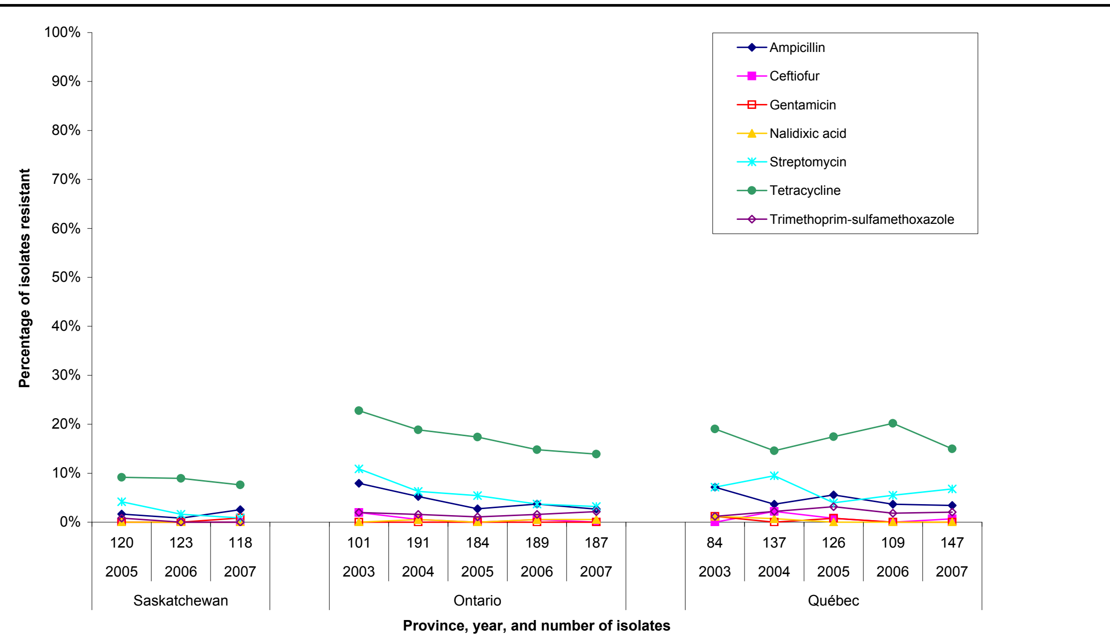


Figure 7. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef; *Retail Meat Surveillance*, 2003–2007.



Campylobacter

Abattoir Surveillance

(n = 73)

Recovery: *Campylobacter* isolates were recovered from 39% (75/190) of beef cattle cecal samples (Table B.4.3 in Appendix B). Two isolates could not be cultured after freezing. Forty-eight percent (35/73) of the remaining isolates were *C. coli*, 41% (30/73) were *C. jejuni*, and 11% (8/73) were other *Campylobacter* spp.

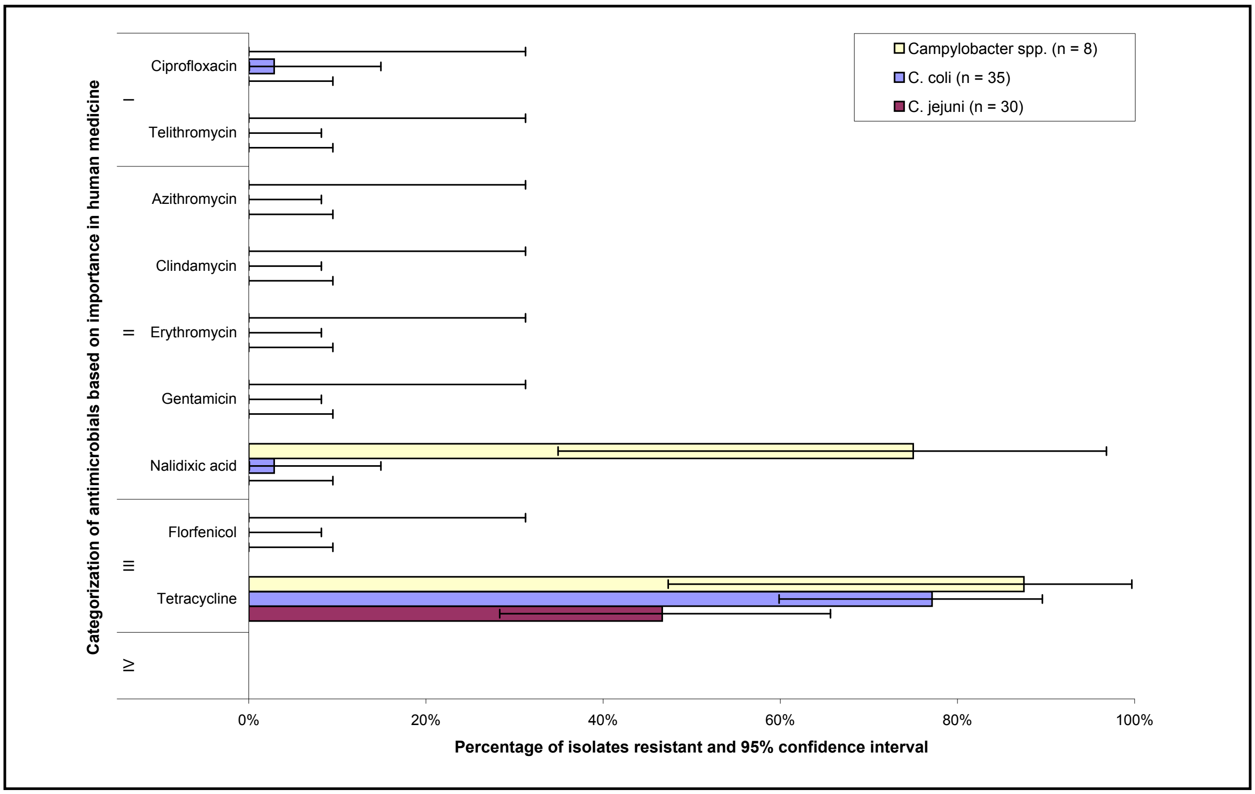
Antimicrobial Resistance: Results are presented in Figure 8 and Table B.2.4 (Appendix B). Resistance to ciprofloxacin was detected in 1 *C. coli* isolate. Six of the 8 other *Campylobacter* spp. isolates were resistant to nalidixic acid, but these species of *Campylobacter* may have included some that were intrinsically resistant to nalidixic acid. None of the isolates were resistant to telithromycin, azithromycin, clindamycin, erythromycin, or gentamicin or were non-susceptible to florfenicol.

Antimicrobial Resistance Patterns: Results are presented in Table 11. Resistance to 1 or more antimicrobials was detected in 66% (48/73) of *Campylobacter* isolates. None of the isolates were resistant to 3 or more antimicrobials. The most common resistance patterns were tetracycline alone (56%, 41/73) and NAL-TET (8%, 6/73).

Temporal variations: The percentage of *Campylobacter* isolates with tetracycline resistance was significantly higher in 2007 (66%, 23/73) than in 2006 (45%, 37/82). There were no other significant temporal variations.

In 2007, resistance to 1 or more antimicrobials was detected in 66% (48/73) of *Campylobacter* isolates recovered from beef cattle cecal samples. Resistance to ciprofloxacin was detected in 1 *C. coli* isolate.

Figure 8. Resistance to antimicrobials in *Campylobacter* isolates from beef cattle; *Abattoir Surveillance*, 2007.



Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

Table 11. Number of antimicrobials in resistance patterns of *Campylobacter* isolates from beef cattle, by *Campylobacter* species; *Abattoir Surveillance*, 2007.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 2	3 - 4	5 - 9
		Number of isolates			
C. coli	35 (47.9)	8	27	0	0
C. jejuni	30 (41.1)	16	14	0	0
Campylobacter spp.	8 (11)	1	7	0	0
Total	**73 (100)**	**25**	**48**	**0**	**0**

Chickens

Salmonella

Abattoir Surveillance

(n = 206)

Recovery: *Salmonella* isolates were recovered from 25% (206/808) of chicken caecal samples (Table B.4.3 in Appendix B).

Serovars: Results are presented in Table 12. The most common *Salmonella* serovars were Kentucky (43%, 89/206), Heidelberg (18%, 37/206), and Enteritidis (10%, 20/206). These 3 serovars accounted for 71% (146/206) of the isolates.

Antimicrobial Resistance: Results are presented in Figure 9 and Table B.2.5 (Appendix B). The percentage of all *Salmonella* isolates resistant to amoxicillin-clavulanic acid and to ceftiofur was the same (12%, 25/206). Intermediate susceptibility to ceftriaxone was detected in 6% (13/206) of isolates. None of the isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin, nalidixic acid, trimethoprim-sulfamethoxazole or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 12. Resistance to 1 or more antimicrobials was detected in 54% (112/206) of isolates. Resistance to 5 or more antimicrobials was detected in 7% (14/206). The most common resistance pattern was STR-TET (28%, 57/206). Eleven percent (22/206) of isolates had the A2C-AMP resistance pattern.

The predominant serovars among isolates with the A2C-AMP resistance pattern were Kentucky (45%, 10/22) and Heidelberg (32%, 7/22). Resistance patterns for *S.* Kentucky isolates included A2C-AMP-TET (2%, 2/89), A2C-AMP-STR (1%, 1/89), and AMC-AMP-TIO-STR-TET (2%, 2/89), as well as the resistance pattern involving the most antimicrobials (A2C-AMP-STR-TET; 8%, 7/89). The ACSSuT resistance pattern was detected in 1% (3/206) of all isolates, which consisted of 2 of 7 *S.* Typhimurium isolates and 1 of 4 *S.* Typhimurium var 5- isolates.

Temporal variations: Results are presented in Figure 10. The percentages of *Salmonella* isolates with resistance to streptomycin or tetracycline were significantly higher in 2007 (37% [77/206] and 44% [91/206], respectively) than in 2003 (24% [30/126] and 19% [24/126], respectively). On the other hand, the percentage of isolates with resistance to ceftiofur was significantly lower in 2007 (12%) than in 2004 (22%, 31/141).[15] In addition, the percentage of isolates with resistance to gentamicin was significantly lower in 2007 (0%) than in 2003 (5%, 6/126). For the first time since the beginning of CIPARS surveillance, resistance to at least one antimicrobial was detected in one isolate of serovar Enteritidis from chicken sources and it was resistant to tetracycline alone.

In 2007, 11% (22/206) of *Salmonella* isolates from abattoir chickens had the A2C-AMP resistance pattern. Intermediate susceptibility to ceftriaxone was detected in 6% (13/206) of isolates. The predominant serovars among isolates with the A2C-AMP resistance pattern were Kentucky (45%, 10/22) and Heidelberg (32%, 7/22). The percentages of *Salmonella* isolates with resistance to streptomycin and tetracycline were significantly higher in 2007 (37% [77/206] and 44% [91/206], respectively) than in 2003 (24% [30/126] and 19% [24/126], respectively). On the other hand, the percentage of isolates with resistance to ceftiofur was significantly lower in 2007 (12%) than in 2004 (22%, 31/141). For the first time since the beginning of CIPARS surveillance, resistance to at least one antimicrobial was detected in one isolate of serovar Enteritidis from chicken sources and it was resistant to tetracycline alone.

[15] 2004 was selected as the year of comparison for results for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Figure 9. Resistance to antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2007.

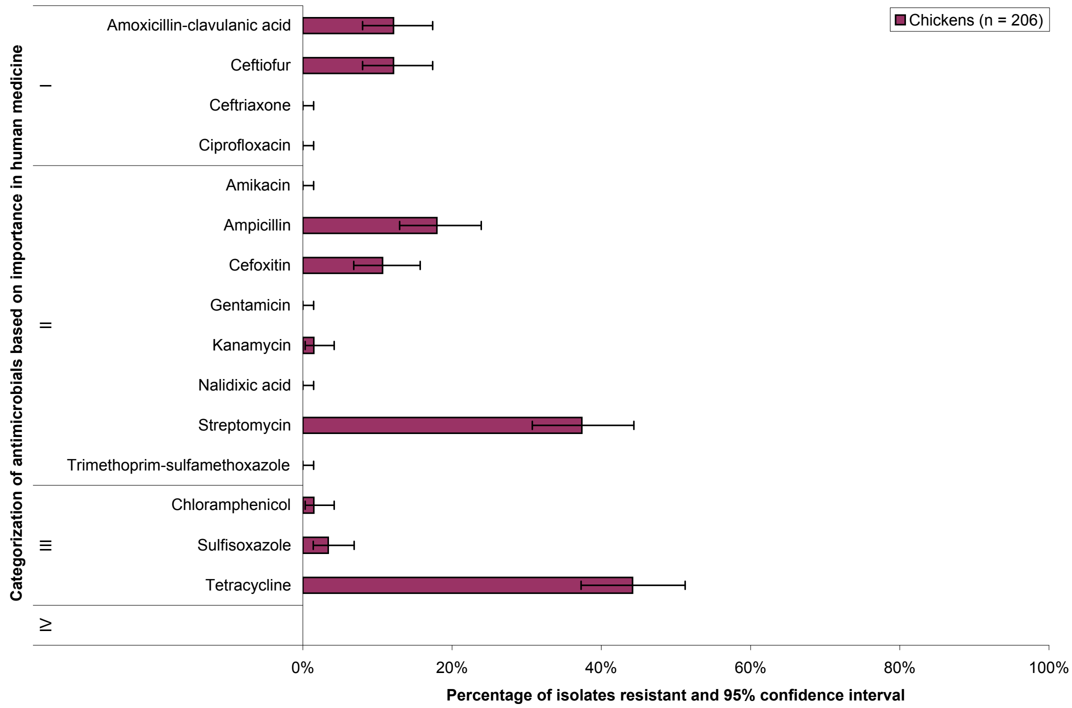
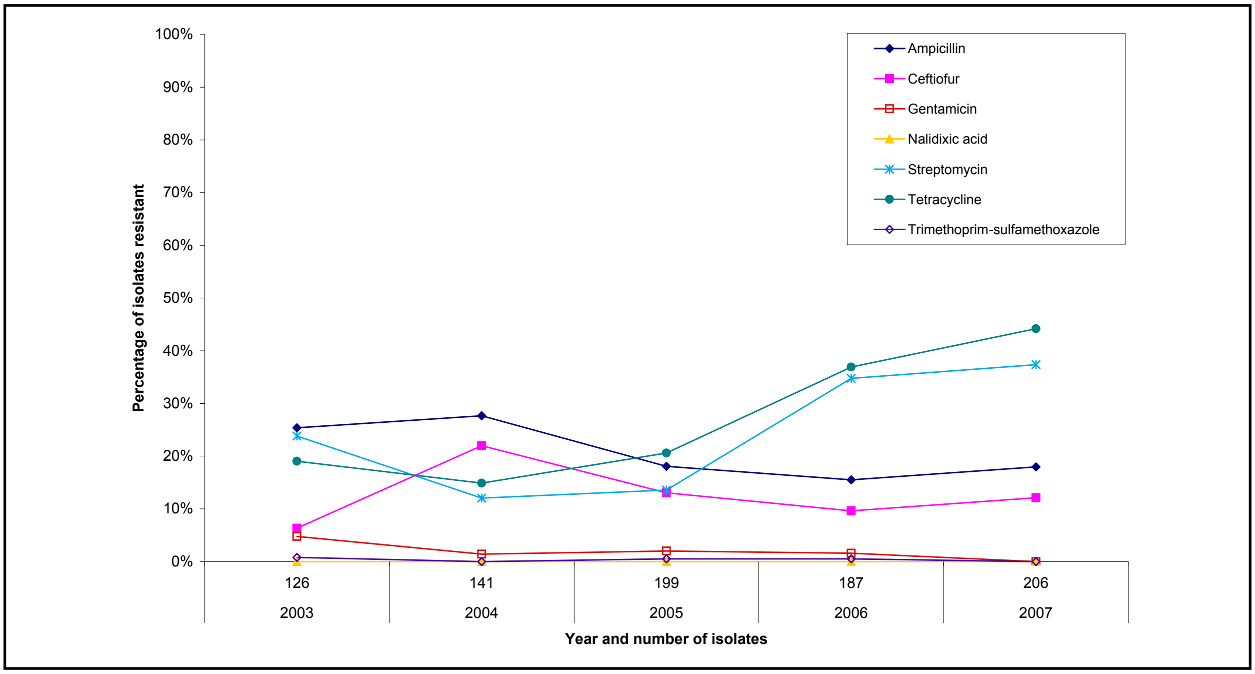


Table 12. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chickens, by serovar; *Abattoir Surveillance*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Kentucky	89 (43.2)	21	57	11	0
Heidelberg	37 (18)	23	14	0	0
Enteritidis	20 (9.7)	19	1	0	0
Hadar	10 (4.9)	1	9	0	0
Typhimurium	7 (3.4)	4	1	2	0
Kiambu	6 (2.9)	4	2	0	0
Less common serovars	37 (18)	22	14	1	0
Total	**206 (100)**	**94**	**98**	**14**	**0**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Figure 10. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2003–2007.



Salmonella

Retail Meat Surveillance

(n = 346)

(British Columbia, n = 18; Saskatchewan, n = 43; Ontario, n = 172; Québec, n = 113)

Recovery: *Salmonella* isolates were recovered from 42% (346/829) of all retail chicken samples (Table B.4.3 in Appendix B). Province-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 22% (18/81); Saskatchewan, 30% (43/141); Ontario, 54% (172/320); and Québec, 40% (113/287).

Serovars: Results are presented in Table 13. The most common *Salmonella* serovars recovered from retail chicken were Kentucky (32%, 110/346), Heidelberg (25%, 87/346), Hadar (6%, 22/346), and Enteritidis (5%, 17/346). In British Columbia, Saskatchewan, and Québec, the most common *Salmonella* serovars were Heidelberg and Kentucky. In Ontario, the most common serovar was Kentucky. Isolates of Hadar accounted for 19% (8/43) of all retail chicken *Salmonella* isolates from Saskatchewan.

Antimicrobial Resistance: Results are presented in Figure 11 and Table B.2.6 (Appendix B). Resistance to amoxicillin-clavulanic acid and ceftiofur was detected in 6 of 18 *Salmonella* isolates from British Columbia, 1 isolate from Saskatchewan, and 11% (19/172) of isolates from Ontario. Eight percent (9/113) of isolates from Québec were resistant to amoxicillin-clavulanic acid, and 9% (10/113) were resistant to ceftiofur. Intermediate susceptibility to ceftriaxone was detected in 3 isolates from British Columbia, 1 isolate from Saskatchewan, 7% (12/172) of isolates from Ontario, and 6% (7/113) of isolates from Québec. Reduced susceptibility to ciprofloxacin was not detected. The percentage of isolates from British Columbia with resistance to amoxicillin-clavulanic acid, ceftiofur, and cefoxitin was significantly higher than the percentage of similarly resistant isolates from Saskatchewan. There were no significant differences among the provinces in percentages of resistant isolates for any of the other antimicrobials tested. None of the isolates from the 4 provinces were resistant to ceftriaxone, ciprofloxacin, amikacin, or nalidixic acid.

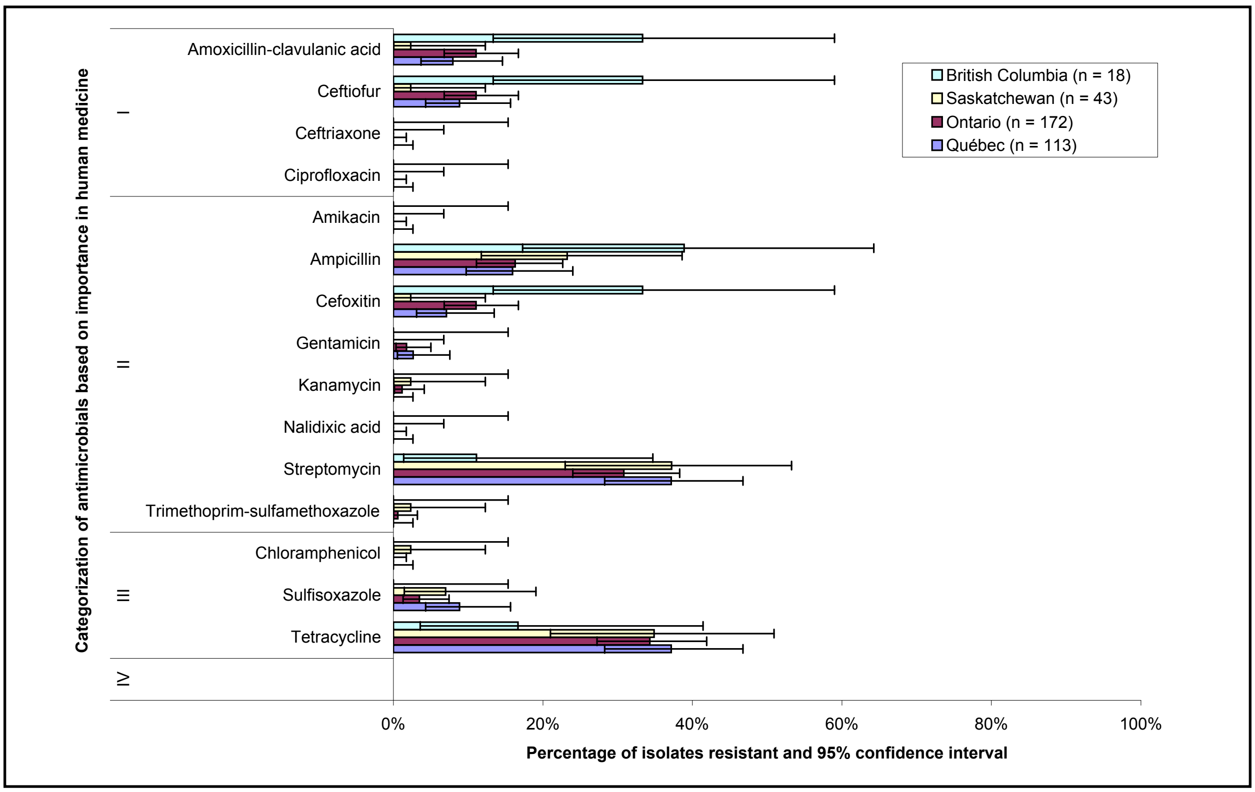
Antimicrobial Resistance Patterns: Results are presented in Table 13. Resistance to 1 or more antimicrobials was detected in 9 of 18 *Salmonella* isolates from British Columbia, 56% (24/43) of isolates from Saskatchewan, 50% (86/172) of isolates from Ontario, and 53% (60/113) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 1 isolate from each British Columbia (*S.* Kentucky) and Saskatchewan (*S.* Typhimurium), 2% (4/172) of isolates from Ontario (all *S.* Kentucky), and 4% (4/113) of isolates from Québec (2 *S.* Heidelberg, 1 *S.* Kentucky, and 1 *S.* Kiambu).

Among isolates from all 4 provinces, the most common resistance patterns were STR-TET (23%, 79/346), A2C-AMP (8%, 26/346), and tetracycline alone (5%, 16/346). The A2C-AMP pattern was detected in 10% (34/346) of isolates, including 23 isolates with intermediate susceptibility to ceftriaxone. The ACSSuT resistance pattern was detected in 1 isolate.

Temporal variations: Results are presented in Figure 12. In Ontario, the percentage of isolates resistant to streptomycin (31%, 53/172) and tetracycline (34%, 59/172) was significantly higher in 2007 than in 2003 (4% [1/26] and 0%, [0/26] respectively). In Ontario and Québec, the percentage of isolates resistant to ceftiofur was significantly lower in 2007 (11% and 9%, respectively) than in 2004 (45% [25/55] and 37% [22/60], respectively).[16] In Ontario and Québec, the percentage of isolates resistant to ampicillin was significantly lower in 2007 (16% [28/172] and 16% [18/113], respectively) than in 2004 (51% [28/55] and 47% [28/60], respectively). No significant temporal variations were detected in Saskatchewan.

In 2007, the percentage of *Salmonella* retail chicken isolates from British Columbia with resistance to amoxicillin-clavulanic acid, ceftiofur, and cefoxitin was significantly higher than the percentage of similarly resistant isolates from Saskatchewan. In Ontario, the percentage of *Salmonella* isolates from retail chicken with resistance to streptomycin (31%, 53/172) and tetracycline (34%, 59/172) was significantly higher in 2007 than in 2003 (4% [1/26] and 0% [0/26], respectively). In Ontario and Québec, the percentage of isolates with resistance to ceftiofur was significantly lower in 2007 (11% [19/172] and 9% [10/113], respectively) than in 2004 (45% [25/55] and 37% [22/60], respectively).

Figure 11. Resistance to antimicrobials in *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2007.



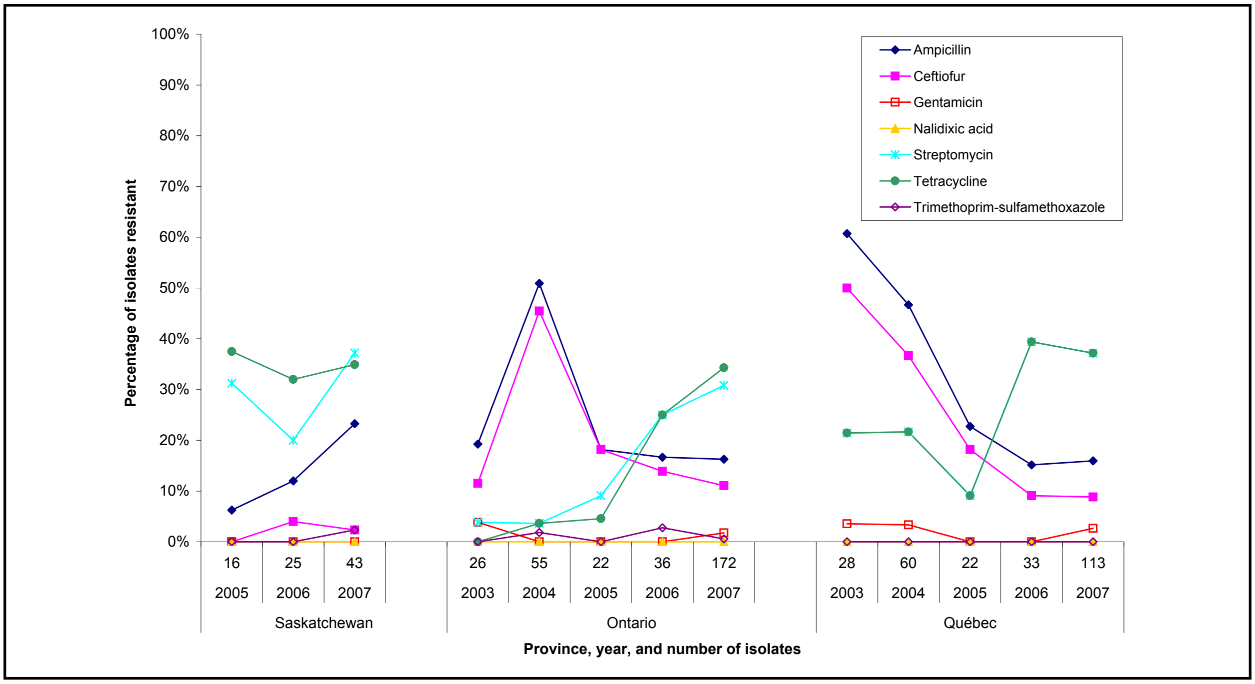
[16] 2004 was selected as the year of comparison for results for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Table 13. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chicken, by province and serovar; *Retail Meat Surveillance*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
British Columbia					
Heidelberg	4 (22.2)	1	3	0	0
Kentucky	4 (22.2)	1	2	1	0
Brandenburg	2 (11.1)	2	0	0	0
Hadar	1 (5.6)	0	1	0	0
I 4:l,v:-	1 (5.6)	1	0	0	0
I 4:r:-	1 (5.6)	0	1	0	0
I 6,7,14:k:-	1 (5.6)	1	0	0	0
Montevideo	1 (5.6)	1	0	0	0
Rissen	1 (5.6)	0	1	0	0
Schwarzengrund	1 (5.6)	1	0	0	0
Thompson	1 (5.6)	1	0	0	0
Total	18 (100)	9	8	1	0
Saskatchewan					
Heidelberg	9 (20.9)	2	7	0	0
Hadar	8 (18.6)	1	7	0	0
Kentucky	6 (14)	2	4	0	0
Infantis	3 (7)	3	0	0	0
Typhimurium	3 (7)	2	0	1	0
Berta	2 (4.7)	1	1	0	0
Enteritidis	2 (4.7)	2	0	0	0
Agona	1 (2.3)	1	0	0	0
Alachua	1 (2.3)	1	0	0	0
Albany	1 (2.3)	1	0	0	0
I 4:i:-	1 (2.3)	0	1	0	0
I 6,7,14:-:5	1 (2.3)	1	0	0	0
Kiambu	1 (2.3)	0	1	0	0
Mbandaka	1 (2.3)	0	1	0	0
Orion	1 (2.3)	0	1	0	0
Schwarzengrund	1 (2.3)	1	0	0	0
Thompson	1 (2.3)	1	0	0	0
Total	43 (100)	19	23	1	0
Ontario					
Kentucky	70 (40.7)	20	46	4	0
Heidelberg	42 (24.4)	27	15	0	0
Enteritidis	10 (5.8)	10	0	0	0
Kiambu	10 (5.8)	6	4	0	0
Hadar	8 (4.7)	0	8	0	0
I 4:i:-	5 (2.9)	3	2	0	0
Typhimurium	5 (2.9)	5	0	0	0
Less common serovars	22 (12.8)	15	7	0	0
Total	172 (100)	86	82	4	0
Québec					
Heidelberg	32 (28.3)	18	12	2	0
Kentucky	30 (26.5)	4	25	1	0
Thompson	11 (9.7)	11	0	0	0
Schwarzengrund	6 (5.3)	0	6	0	0
Enteritidis	5 (4.4)	5	0	0	0
Hadar	5 (4.4)	0	5	0	0
Infantis	5 (4.4)	5	0	0	0
Agona	4 (3.5)	2	2	0	0
Kiambu	3 (2.7)	1	1	1	0
Less common serovars	12 (10.6)	7	5	0	0
Total	113 (100)	53	56	4	0
Total	**346 (100)**	**167**	**169**	**10**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

Figure 12. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2003–2007.



Surveillance of Animal Clinical Isolates

(n = 105)

Note: These chickens may have included layer hens and broiler chickens. A proportion of the isolates might have been recovered from environmental samples.

Serovars: Results are presented in Table 14. The most common *Salmonella* serovars were Enteritidis (34%, 36/105), Heidelberg (20%, 21/105), and Kentucky (11%, 12/105). These 3 serovars accounted for 66% (69/105) of all isolates.

Antimicrobial Resistance: Results are presented in Table B.2.7 (Appendix B). Resistance to amoxicillin-clavulanic acid, ceftiofur, and ceftriaxone was detected in 13% (14/105), 13% (14/105), and 1 isolate, respectively. Intermediate susceptibility to ceftriaxone was detected in 8% (8/105) of isolates, respectively. None of the isolates were resistant to ciprofloxacin, amikacin, nalidixic acid, trimethoprim-sulfamethoxazole, or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 14. Resistance to 1 or more antimicrobials was detected in 27% (28/105) of the isolates. Resistance to 5 or more antimicrobials was detected in 4% (4/105) of isolates. The most common resistance patterns were A2C-AMP (10%, 11/105), tetracycline alone (5%, 5/105), and STR-TET (3%, 3/105). The A2C-AKSSuT pattern was detected in 1 isolate, and the ACSSuT resistance pattern was detected in another. Regarding specific *Salmonella* serovars, resistance to 5 or more antimicrobials was detected in 1 isolate each of Kentucky, Senftenberg, Typhimurium, and Bredeney. Eight isolates with the A2C-AMP resistance pattern were *S.* Heidelberg. Four of these *S.* Heidelberg isolates also had intermediate susceptibility to ceftriaxone. The A2C-AMP and A2C-AMP-GEN-STR resistance patterns were detected in 1 *S.* Infantis and 1 *S.* Senftenberg isolate, respectively; these isolates also had intermediate susceptibility to ceftriaxone. The pattern involving resistance to the most antimicrobials was A2C-AKSSuT-CRO-GEN, which was detected in 1 isolate of *S.* Bredeney. This particular resistance pattern-serovar combination has only been detected in clinical turkey isolates during surveillance in previous years (1 isolate in 2002 and 2004, 2 isolates in 2005, and 6 isolates in 2006) and in 1 unspecified avian isolate in 2005.

In 2007, resistance to 1 or more antimicrobials was detected in 27% (28/105) of all chicken clinical isolates of *Salmonella*. One of the most common resistance pattern was A2C-AMP (10%, 11/105). The pattern involving resistance to the most antimicrobials was A2C-AKSSuT-CRO-GEN, which was detected in for the first time in 1 *S.* Bredeney chicken isolate.

Table 14. Number of antimicrobials in resistance patterns of *Salmonella* isolates from chickens, by serovar; *Surveillance of Animal Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Enteritidis	36 (34.3)	36	0	0	0
Heidelberg	21 (20)	11	10	0	0
Kentucky	12 (11.4)	8	3	1	0
Typhimurium	10 (9.5)	9	0	1	0
I:4,12:i:-	4 (3.8)	2	2	0	0
Infantis	4 (3.8)	2	2	0	0
I:8,20:-:z6	3 (2.9)	0	3	0	0
Less common serovars	15 (14.3)	9	4	1	1
Total	**105 (100)**	**77**	**24**	**3**	**1**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Escherichia coli

Abattoir Surveillance

(n = 180)

Recovery: *Escherichia coli* isolates were recovered from 99% (180/181) of abattoir chicken caecal samples (Table B.4.3 in Appendix B).

Antimicrobial Resistance: Results are presented in Figure 13 and Table B.2.8 (Appendix B). Resistance to amoxicillin-clavulanic acid and ceftiofur was detected in 27% (48/180) and 26% (47/180) of the *E. coli* isolates, respectively. Intermediate susceptibility to ceftriaxone was detected in 14% (26/180), and reduced susceptibility to ciprofloxacin was detected in 2% (3/180). Resistance to nalidixic acid was detected in 2% (4/180) of isolates. None of the isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 77% (138/180) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 21% (38/180). The most common resistance patterns were STR-TET (7%, 13/180), tetracycline alone (7%, 12/180), and A2C-AMP (6%, 11/180). The A2C-ACSSuT, and A2C-AKSSuT resistance patterns were detected in 4% (7/180) and 2% (3/180) of isolates, respectively.

Temporal variations: Results are presented in Figure 14. The percentages of *E. coli* isolates with resistance to streptomycin and tetracycline were significantly lower in 2007 (40% [72/180] and 57% [103/180], respectively) than in 2003 (52% [88/153] and 69% [106/153], respectively).

In 2007, 14% (26/180) of *Escherichia coli* isolates recovered from abattoir chicken samples had intermediate susceptibility to ceftriaxone, and 2% (3/180) had reduced susceptibility to ciprofloxacin. Resistance to nalidixic acid was detected in 2% (4/180) of isolates.

Figure 13. Resistance to antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance*, 2007.

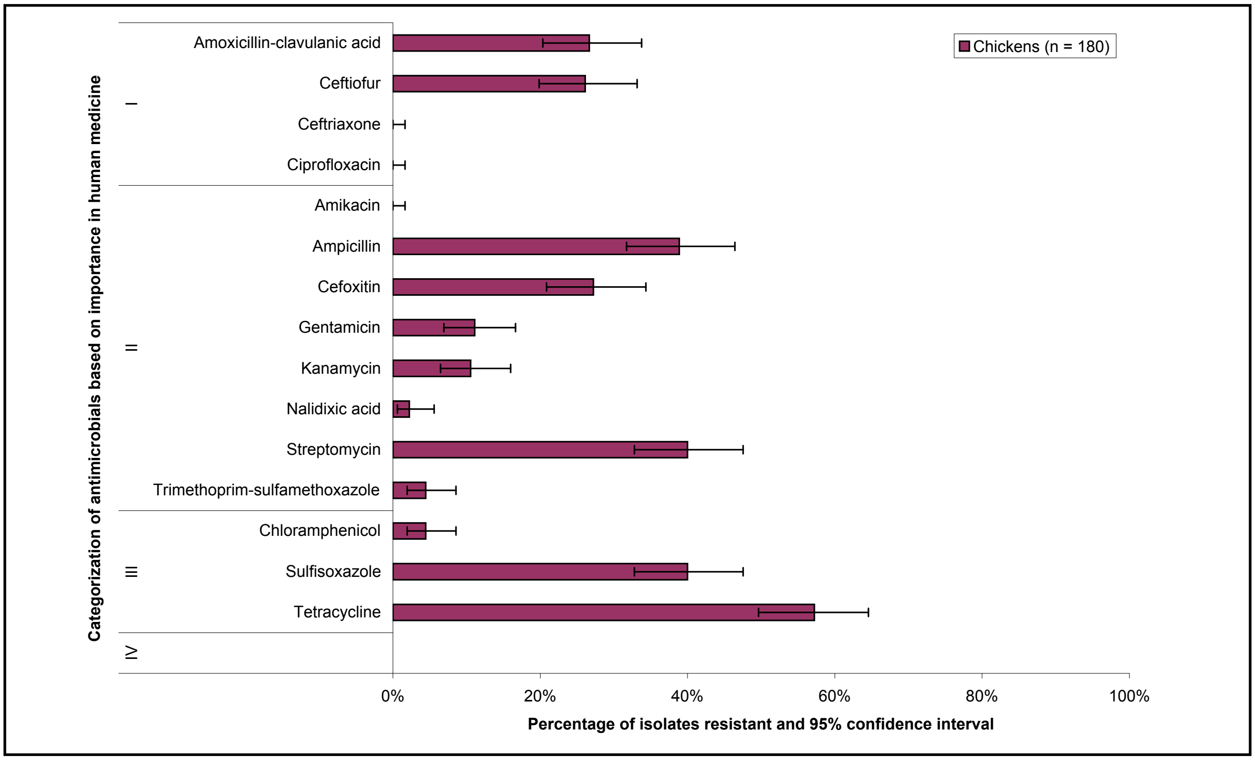
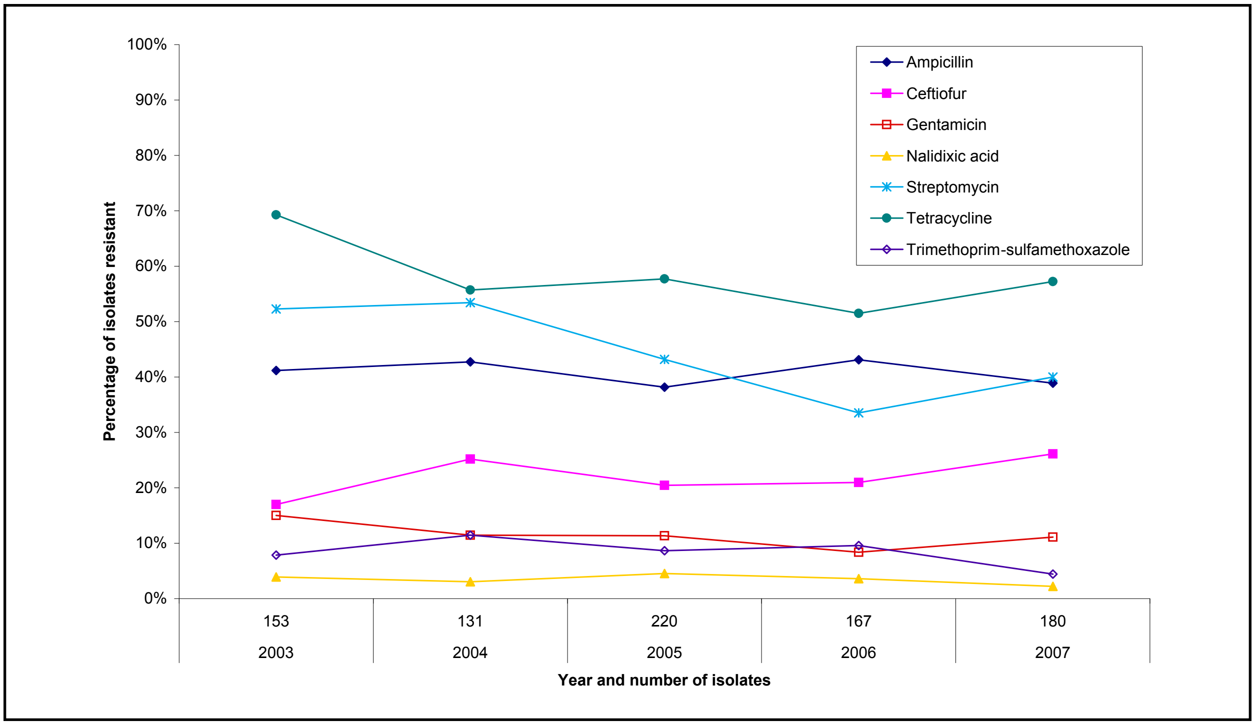


Figure 14. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance*, 2003–2007.



Retail Meat Surveillance

(n = 402)
(British Columbia, n = 42; Saskatchewan, n = 75; Ontario, n = 157; Québec, n = 128)

Recovery: *Escherichia coli* isolates were recovered from 95% (403/425) of all retail chicken samples (Table B.4.3 in Appendix B). Province-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 100% (42/42); Saskatchewan, 97% (75/77); Ontario, 98% (157/161); and Québec, 89% (128/144).

Antimicrobial Resistance: Results are presented in Figure 15 and Table B.2.9 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 33% (14/42) of *E. coli* isolates from British Columbia, 17% (13/75) of isolates from Saskatchewan, 27% (42/157) of isolates from Ontario, and 18% (23/128) of isolates from Québec. Resistance to ceftiofur was detected in 29% (12/42) of isolates from British Columbia, 13% (10/75) of isolates from Saskatchewan, 22% (35/157) of isolates from Ontario, and 13% (17/128) of isolates from Québec. One isolate from Ontario was resistant to ceftriaxone. Intermediate susceptibility to ceftriaxone was detected in 7% (3/42) of isolates from British Columbia, 5% (4/75) of isolates from Saskatchewan, 6% (9/157) of isolates from Ontario, and 6% (8/128) of isolates from Québec. Reduced susceptibility to ciprofloxacin was detected in 5% (2/42) of isolates from British Columbia, 5% (4/75) of isolates from Saskatchewan, 3% (5/157) of isolates from Ontario, and 3% (4/128) of isolates from Québec. The percentage of isolates resistant to gentamicin was significantly higher in Québec than in British Columbia. The percentage of isolates resistant to sulfisoxazole was significantly higher in Québec than in Ontario. There were no significant differences among provinces in percentages of resistant isolates for any other antimicrobial tested. None of the isolates from any province were resistant to ciprofloxacin or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 76% (32/42) of *E. coli* isolates from British Columbia, 72% (54/75) of isolates from Saskatchewan, 73% (114/157) of isolates from Ontario, and 74% (95/128) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 14% (6/42) of isolates from British Columbia, 16% (12/75) of isolates from Saskatchewan, 22% (34/157) of isolates from Ontario, and 20% (26/128) of isolates from Québec. The most common resistance patterns were tetracycline alone (10%, 41/402), A2C-AMP (7%, 29/402), and GEN-STR-SSS (3%, 14/402). The A2C-AMP pattern, alone or in combination with other antimicrobials, was detected in 18% (71/402) of isolates. Two percent (7/402) had the ACSSuT resistance pattern, 3% (11/402) had the AKSSuT pattern, and 1% (2/402) had the ACKSSuT pattern. Two isolates from Ontario and 1 isolate from British Columbia had the A2C-ACSSuT pattern, 1 isolate from Québec had at the A2C-AKSSuT pattern, and 1 isolate from Saskatchewan had the A2C-ACKSSuT pattern.

Temporal variations: Results are presented in Figure 16. The percentage of *E. coli* isolates from Québec with ampicillin resistance was significantly lower in 2007 (34%, 144/128) than in 2004 (52%, 82/158). The percentage of isolates from Québec with ceftiofur resistance was significantly lower in 2007 (13%) than in 2004 (34%, 53/157),[17] whereas the percentage of isolates with ceftiofur resistance from Saskatchewan was significantly higher in 2007 (13%) than in 2005 (4%, 3/82). No significant temporal variations were identified in Ontario.

In 2007, 1 of 75 *Escherichia coli* isolates from Ontario retail chicken was resistant to ceftriaxone. The percentage of isolates from Québec with ceftiofur resistance was significantly lower in 2007 (13%, 17/128) than in 2004 (34%, 53/157), whereas the percentage of isolates from Saskatchewan with resistance to ceftiofur was significantly higher in 2007 (13%, 10/75) than in 2005 (4%, 3/82).

[17] 2004 was selected as the year of comparison for results for ceftiofur and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Figure 15. Resistance to antimicrobials in *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2007.

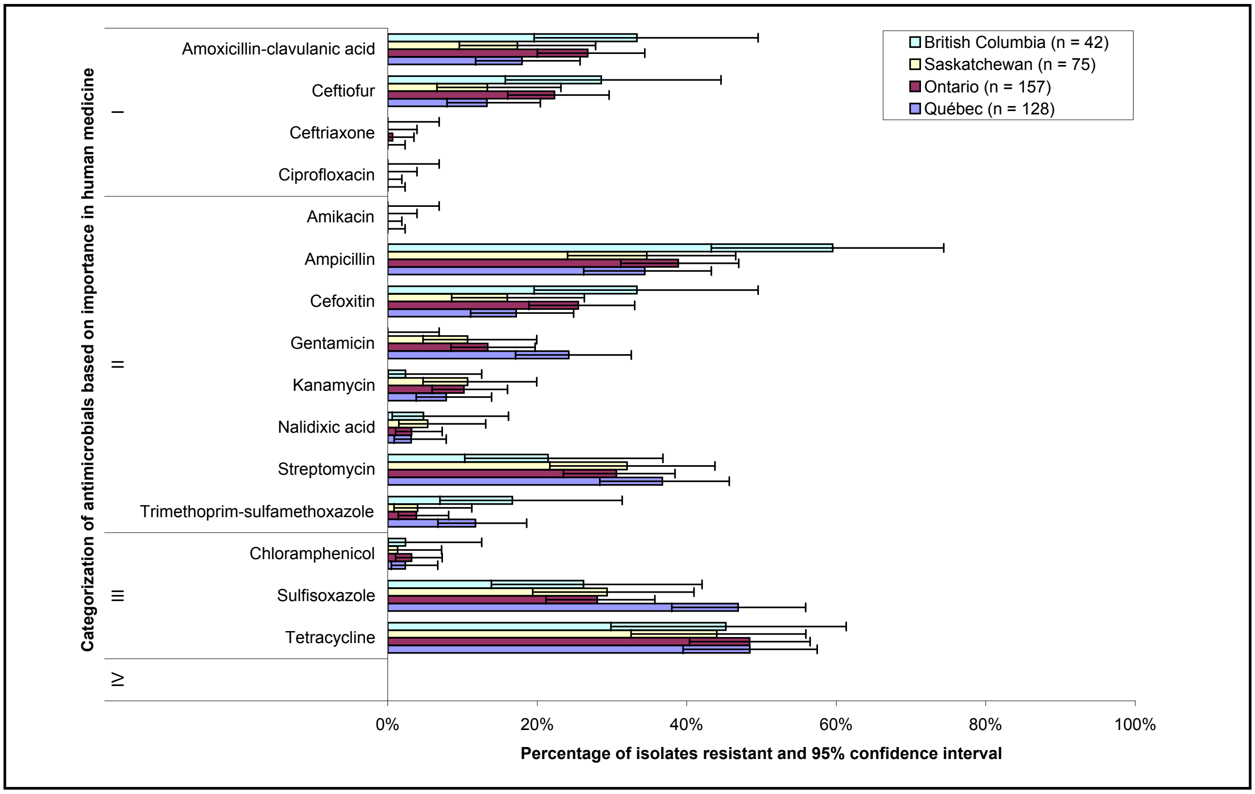
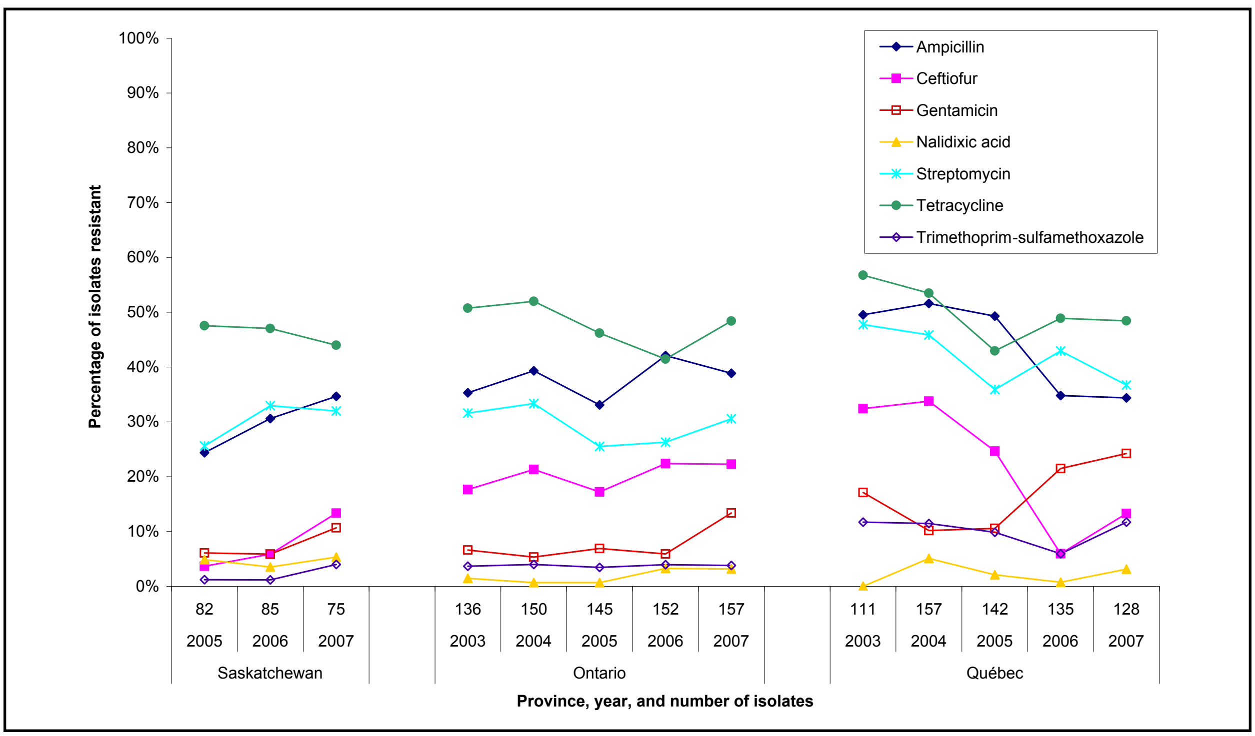


Figure 16. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2003–2007.



Campylobacter

Retail Meat Surveillance

(n = 253)
(British Columbia, n = 28; Saskatchewan, n = 49; Ontario, n = 117; Québec n = 59)

Recovery: *Campylobacter* isolates were recovered from 31% (253/828) of retail chicken samples (Table B.4.3 in Appendix B). Eighty-one percent (206/253) of the isolates were *C. jejuni*, 17% (43/253) were *C. coli*, and 2% (4/253) were other *Campylobacter* spp. Province-specific percentages of chicken samples from which isolates were recovered were as follows: British Columbia, 35% (28/80); Saskatchewan, 35% (49/141); Ontario, 37% (117/320); and Québec, 21% (59/287).

Antimicrobial Resistance: Results are presented in Figure 17, Figure 18, and Table B.2.10 (Appendix B). Resistance to telithromycin was detected in 1 isolate from each of Saskatchewan and Ontario and in 5% (3/59) of isolates from Québec. The distribution of these telithromycin-resistant isolates according to species of *Campylobacter* was as follows: *C. coli*, 9% (4/43) and *C. jejuni*, 1 isolate. Resistance to ciprofloxacin was detected in 1 *Campylobacter* isolate from British Columbia, 6% (3/49) of isolates from Saskatchewan, in 1 isolate from Ontario, and 14% (8/59) of isolates from Québec. The distribution of these ciprofloxacin-resistant isolates according to species of *Campylobacter* was as follows: *C.* coli, 21% (9/43); and *C. jejuni*, 2% (4/206). Resistance to ciprofloxacin was not detected in other *Campylobacter* spp. All isolates that were resistant to ciprofloxacin were also resistant to nalidixic acid. There were no significant differences among the provinces in percentages of resistant isolates for any of the antimicrobials tested. None of the isolates were resistant to gentamicin or were non-susceptible to florfenicol. Additionally, no isolates from British Columbia were resistant to azithromycin, clindamycin, or erythromycin.

Antimicrobial Resistance Patterns: Results are presented in Table 15. Resistance to 1 or more antimicrobials was detected in 39% (11/28) of *Campylobacter* isolates from British Columbia, 39% (19/49) of isolates from Saskatchewan, 58% (68/117) of isolates from Ontario, and 71% (42/59) of isolates from Québec. Resistance to 3 or more antimicrobials was detected in 1 isolate from British Columbia, 8% (4/49) of isolates from Saskatchewan, 2% (2/117) of isolates from Ontario, and 10% (6/59) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were tetracycline alone (47%, 118/253), CIP-NAL (3%, 8/253), and CIP-NAL-TET (2%, 5/253).

Temporal variations: Results are presented in Figure 19. The percentages of *Campylobacter* isolates with resistance to azithromycin and nalidixic acid in Ontario were significantly lower in 2007 (2% [2/117] and 1 isolate, respectively) than in 2003 (9% [7/78] and 10% [8/78], respectively). Similarly, the percentage of isolates from Québec with resistance to tetracycline was significantly lower in 2007 (54%, 32/59) than in 2003 (70%, 66/94).

In 2007, the percentage of *Campylobacter* isolates from retail chicken with resistance to ciprofloxacin was 2% (1/28) for British Columbia, 6% (3/49) for Saskatchewan, less than 1% for Ontario (1/117), and 14% (8/59) for Québec. Among the isolates from all 4 provinces, the most common resistance patterns were tetracycline alone (47%, 118/253), CIP-NAL (3%, 8/253), and CIP-NAL-TET (2%, 5/253). The percentage of isolates with resistance to ciprofloxacin and nalidixic acid was significantly higher in Québec (14%, 8/59) than in Ontario (1 isolate). The percentages of isolates from Ontario with resistance to azithromycin and nalidixic acid were significantly lower in 2007 (2% and 1 isolate, respectively) than in 2003 (9% and 10%, respectively). Similarly, the percentage of isolates from Québec with resistance to tetracycline was significantly lower in 2007 (54%, 32/59) than in 2003 (70%, 66/94).

Figure 17. Resistance to antimicrobials in *Campylobacter* isolates from chicken; *Retail Meat Surveillance*, 2007.

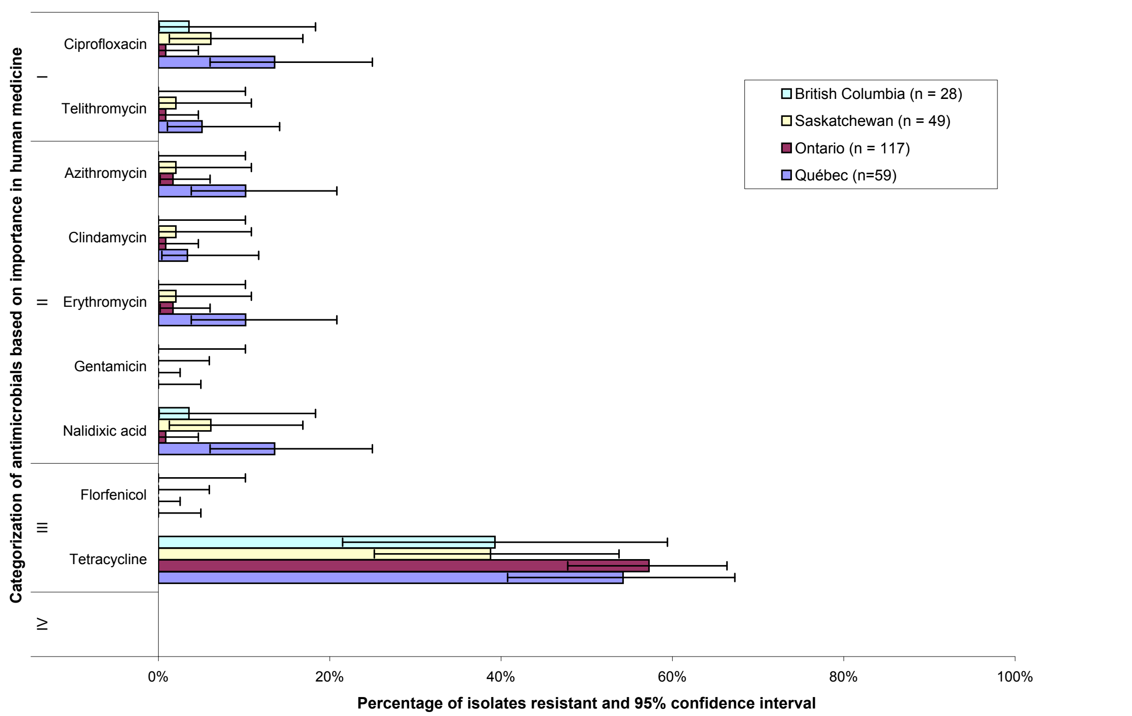
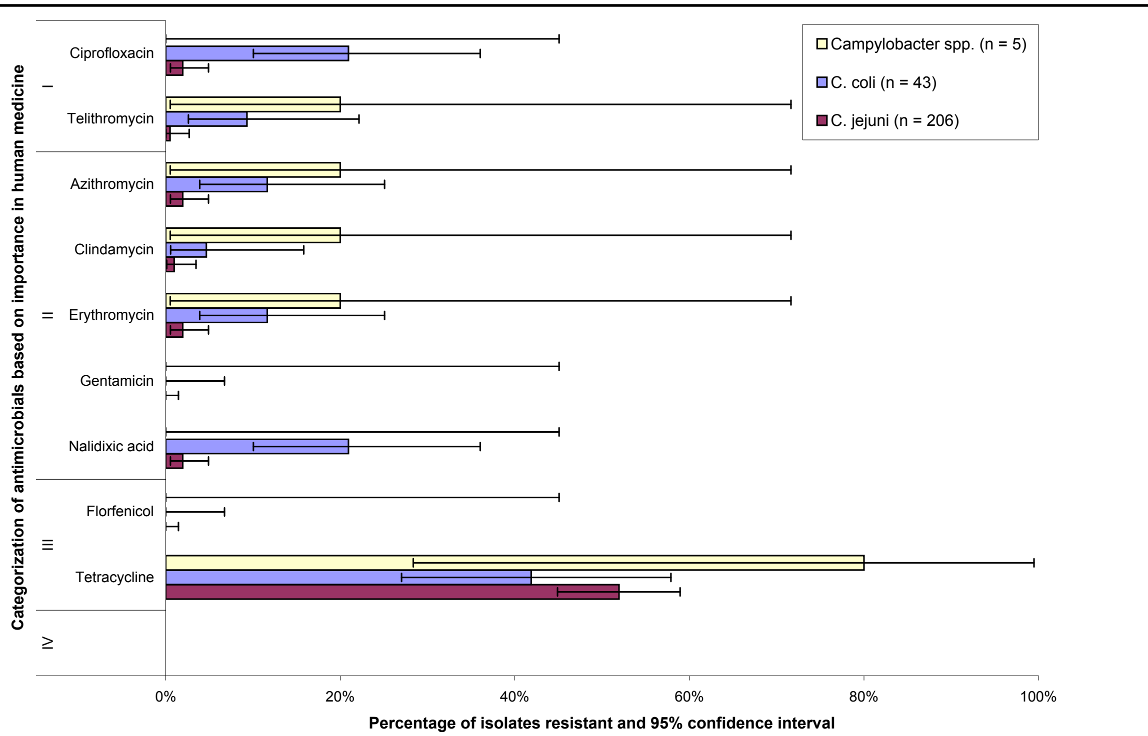


Figure 18. Resistance to antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter* species; *Retail Meat Surveillance*, 2007.

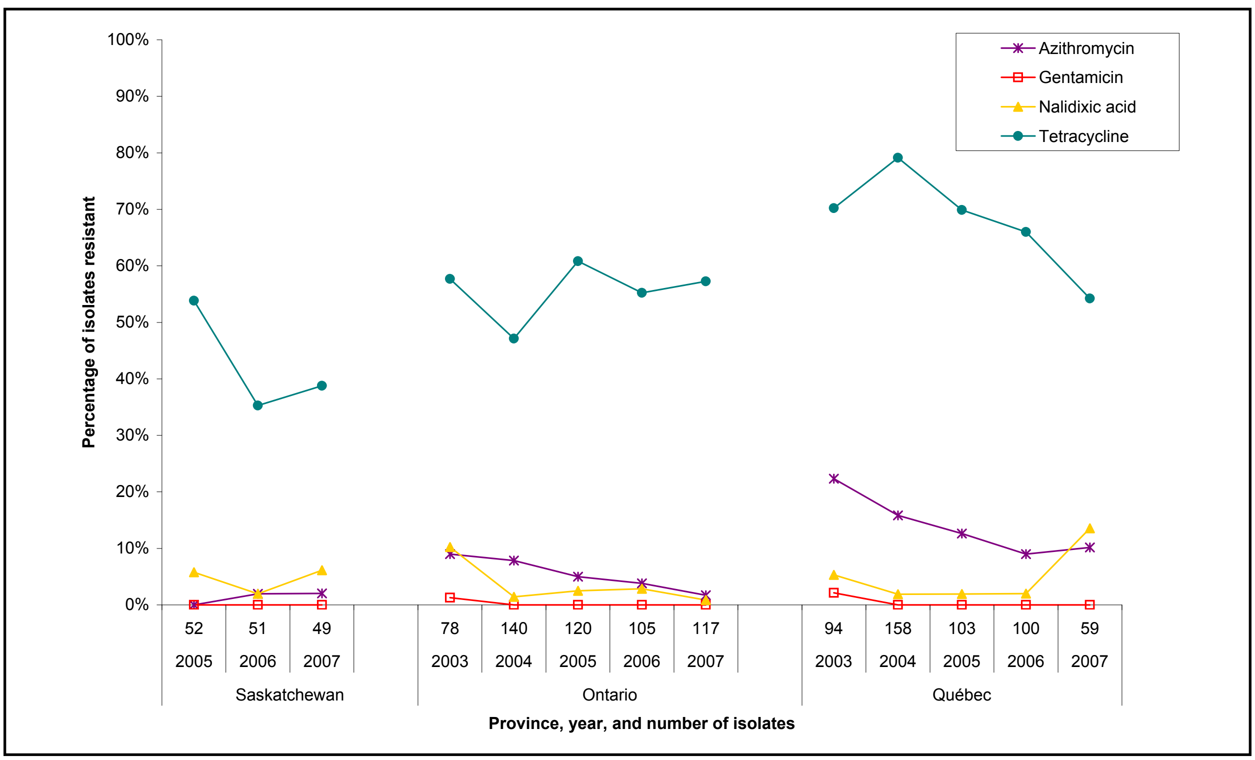


Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

Table 15. Number of antimicrobials in resistance patterns of *Campylobacter* isolates from chicken, by province and *Campylobacter* species; *Retail Meat Surveillance*, 2007.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern 0	1 - 2	3 - 4	5 - 9
		Number of isolates			
British Columbia					
C. jejuni	26 (92.9)	15	10	1	0
C. coli	2 (7.1)	2	0	0	0
Total	28 (100)	17	10	1	0
Saskatchewan					
C. jejuni	39 (79.6)	27	11	1	0
C. coli	10 (20.4)	3	4	2	1
Total	49 (100)	30	15	3	1
Ontario					
C. jejuni	97 (82.9)	41	54	1	1
C. coli	17 (14.5)	8	9	0	0
Campylobacter spp.	3 (2.6)	0	3	0	0
Total	117 (100)	49	66	1	1
Québec					
C. jejuni	44 (74.6)	14	28	2	0
C. coli	14 (23.7)	3	7	3	1
Campylobacter spp.	1 (1.7)	0	1	0	0
Total	59 (100)	17	36	5	1
Total	**253 (100)**	**113**	**127**	**10**	**3**

Figure 19. Temporal variation in resistance to selected antimicrobials in *Campylobacter* isolates from chicken; *Retail Meat Surveillance*, 2003–2007.



Enterococcus

Retail Meat Surveillance

(n = 420)
(British Columbia, n = 42; Saskatchewan, n = 76; Ontario, n = 161; Québec, n = 141)

Recovery: *Enterococcus* isolates were recovered from 99.7% (423/424) of all retail chicken samples (Table B.4.3 in Appendix B). Three isolates could not be cultured after freezing. Ninety-two percent (388/420) of the remaining isolates were *E. faecalis*, 4% (18/420) were other *Enterococcus* spp., and 3% (14/420) were *E. faecium*. Province-specific percentages of chicken samples from which *Enterococcus* was recovered were as follows: British Columbia, 100% (42/42); Saskatchewan, 100% (77/77); Ontario, 100% (161/161); and Québec, 99% (143/144).

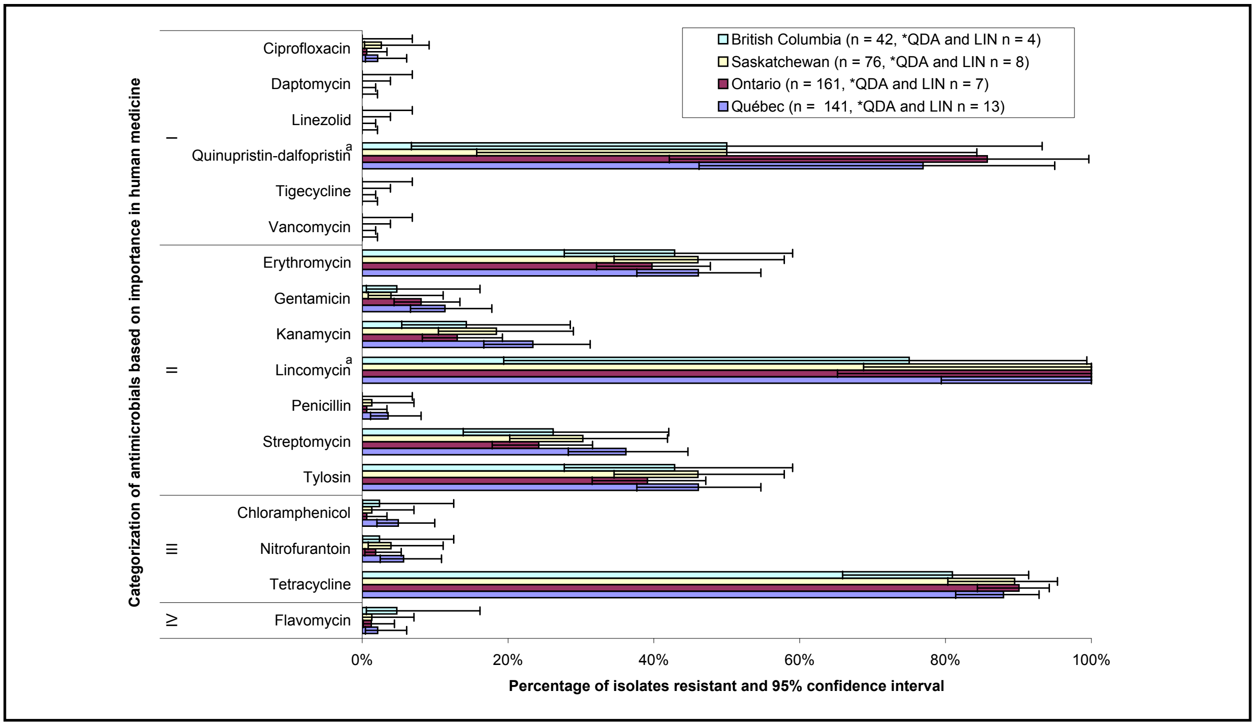
Antimicrobial Resistance: Results are presented in Figure 20, Figure 21, and Table B.2.11 (Appendix B). Resistance to ciprofloxacin was not detected in *Enterococcus* isolates from British Columbia, but was detected in 3% (2/76) of isolates from Saskatchewan, 1 isolate from Ontario, and 2% (3/141) of isolates from Québec. This resistance was detected in isolates of *E. faecium* (4/14), *E. faecalis* (1/388), and other *Enterococcus* spp. (1/18). Resistance to quinupristin-dalfopristin was detected in *Enterococcus* isolates from British Columbia (2/4), from Saskatchewan (4/8), from Ontario (6/7), and from Québec (10/13).There were no significant differences among provinces in percentages of isolates that were resistant to any antimicrobials. None of the isolates from any province were resistant to linezolid, tigecycline, or vancomycin or were non-susceptible to daptomycin.

Antimicrobial Resistance Patterns: Results are presented in Table 16. Resistance to 1 or more antimicrobials was detected in 90% (38/42) of *Enterococcus* isolates from British Columbia, 95% (72/76) of isolates from Saskatchewan, 91% (147/161) of isolates from Ontario, and 89% (125/141) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 17% (7/42) of isolates from British Columbia, 17% (13/76) of isolates from Saskatchewan, 13% (21/161) of isolates from Ontario, and 28% (40/141) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were tetracycline alone (36%, 153/420) and ERY-TET-TYL (15%, 63/420).

Temporal variations: Results are presented in Figure 22. The percentage of *Enterococcus* isolates from Québec with resistance to erythromycin or tylosin was significantly lower in 2007 (46%, 65/141) than in 2003 (66% 82/125). No significant temporal variations were detected in other provinces.

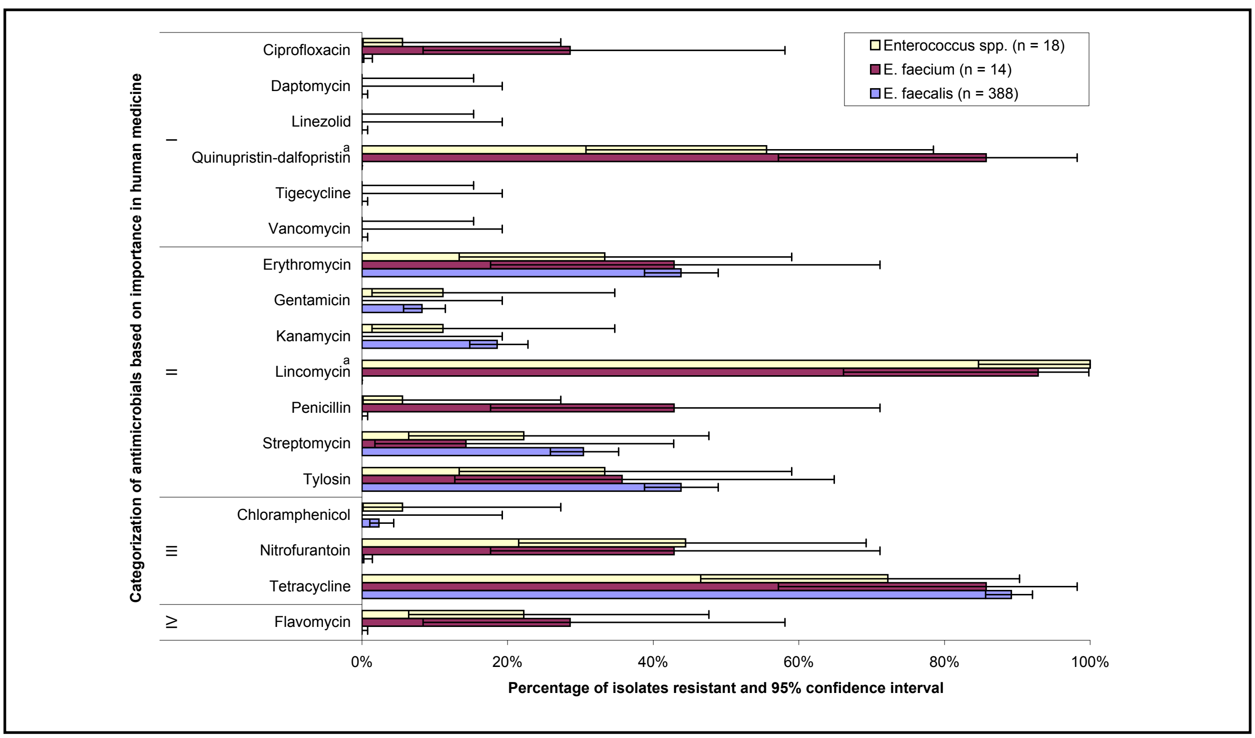
In 2007, resistance to ciprofloxacin was detected in 3% (2/76) of *Enterococcus* from Saskatchewan retail chicken, 1 of 161 isolates from Ontario retail chicken, and 2% (3/141) of isolates from Québec retail chicken. Ciprofloxacin resistance was detected in isolates of *E. faecium* (4/14), *E. faecalis* (1/388), and other *Enterococcus* spp. (1/18). The percentage of Québec isolates with resistance to erythromycin and tylosin was significantly lower in 2007 (46%, 65/141) than in 2003 (66% 82/125).

Figure 20. Resistance to antimicrobials in *Enterococcus* isolates from chicken, by province; *Retail Meat Surveillance*, 2007.



Resistance to quinupristin-dalfopristin (QDA) and lincomycin (LIN) is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Figure 21. Resistance to antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus* species; *Retail Meat Surveillance*, 2007.

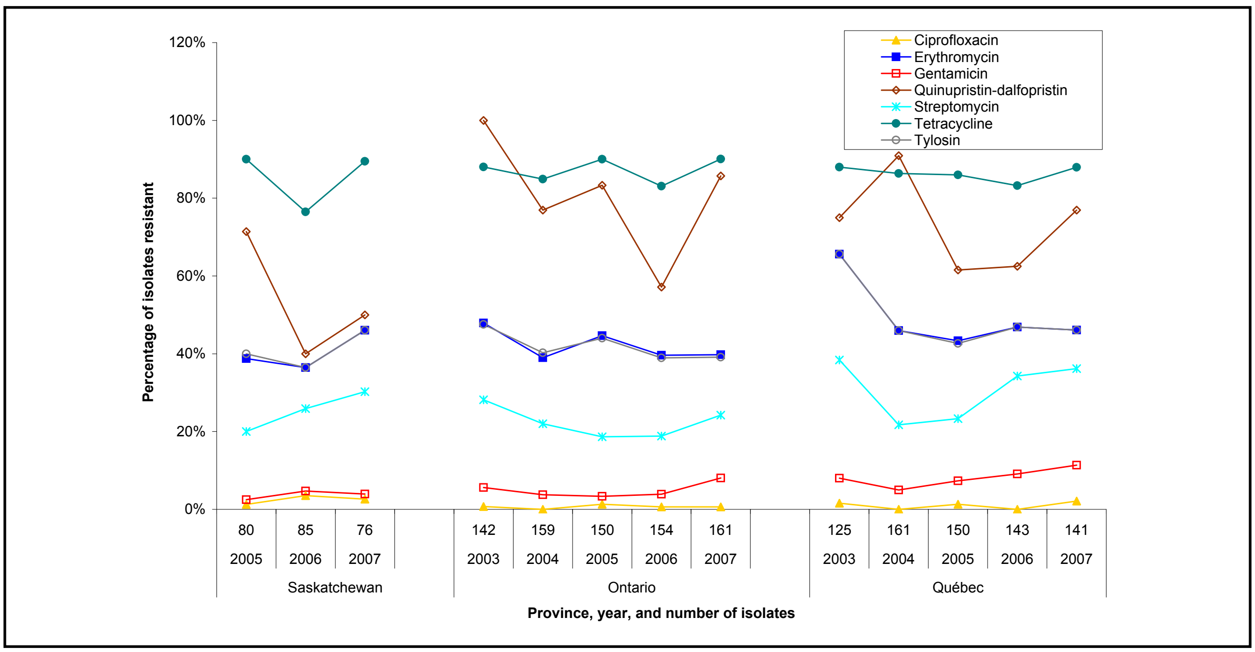


Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Table 16. Number of antimicrobials in resistance patterns of *Enterococcus* isolates from chicken, by *Enterococcus* species; *Retail Meat Surveillance*, 2007.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 17
		Number of isolates			
British Columbia					
E. faecalis	38 (90.5)	4	28	6	0
E. faecium	2 (4.8)	0	2	0	0
Enterococcus spp.	2 (4.8)	0	1	1	0
Total	42 (100)	4	31	7	0
Saskatchewan					
E. faecalis	68 (89.5)	4	54	10	0
Enterococcus spp.	5 (6.6)	0	4	1	0
E. faecium	3 (3.9)	0	1	2	0
Total	76 (100)	4	59	13	0
Ontario					
E. faecalis	154 (95.7)	14	121	19	0
E. faecium	4 (2.5)	0	3	1	0
Enterococcus spp.	3 (1.9)	0	2	1	0
Total	161 (100)	14	126	21	0
Québec					
E. faecalis	128 (90.8)	15	81	32	0
Enterococcus spp.	8 (5.7)	0	5	2	1
E. faecium	5 (3.5)	0	0	5	0
Total	141 (100)	15	86	39	1
Total	**420 (100)**	**37**	**302**	**80**	**1**

Figure 22. Temporal variation in resistance to selected antimicrobials in *Enterococcus* isolates from chicken; *Retail Meat Surveillance*, 2003–2007.



The annual number of isolates tested for quinupristin-dalfopristin was smaller than indicated because no isolates of *E. faecalis* were included in the analysis for this antimicrobial.

Pigs

Salmonella

Farm Surveillance
(n = 110)

Recovery: *Salmonella* isolates were recovered from 22% (136/612) of pig fecal samples.

Serovars: Results are presented in Table 17. The most common *Salmonella* serovars were Typhimurium var. 5- and Derby. These 2 serovars accounted for 39% (43/110) of the isolates.

Antimicrobial Resistance: Results are presented in Figure 23 and Table B.2.12 (Appendix B). None of the *Salmonella* isolates had intermediate susceptibility to ceftriaxone or reduced susceptibility to ciprofloxacin. In addition, none were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, or nalidixic acid.

Antimicrobial Resistance Patterns: Results are presented in Table 17. Resistance to 1 or more antimicrobials was detected in 55% (61/110) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 23% (25/110). Three percent (3/110) of isolates had an AKSSuT resistance pattern. The most common resistance patterns were STR-SSS-TET (11%, 12/110), ACKSSuT (10%, 11/110), and ACSSuT (9%, 10/110).

Regarding specific *Salmonella* serovars, 82% (18/22) of Typhimurium var. 5- isolates and 67% (14/21) of Derby isolates were resistant to 1 antimicrobial. Of those isolates, 45% (10/22) and 5% (1/21) were resistant to 5 or more antimicrobials, respectively.

In 2007, none of the *Salmonella* isolates recovered from pig fecal samples were resistant to Category 1 antimicrobials, or had intermediate susceptibility to ceftriaxone or reduced susceptibility to ciprofloxacin.

Figure 23. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance*, 2007.

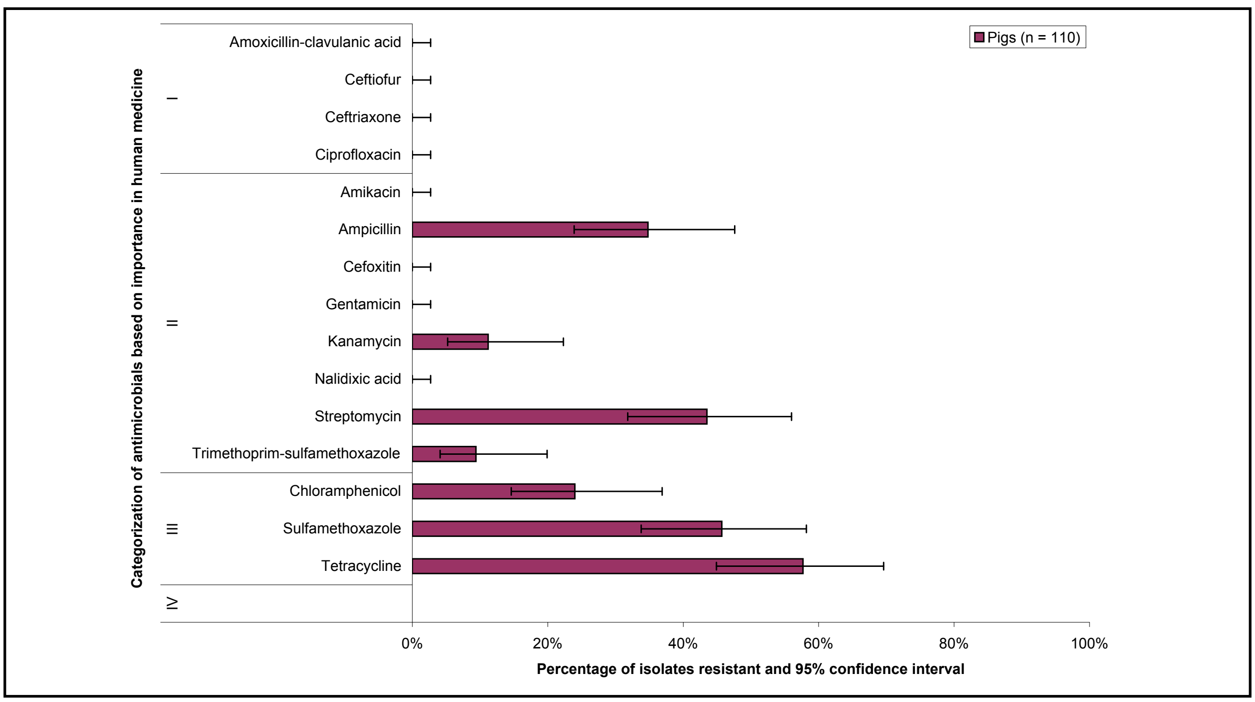


Table 17. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Farm Surveillance*, 2007.

Serovar	number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium var. 5-	22 (20.0)	4	8	10	0
Derby	21 (19.1)	7	13	1	0
Infantis	11 (10.0)	10	1	0	0
Typhimurium	10 (9.1)	1	3	6	0
I 4:i:-	7 (6.4)	0	3	4	0
California	4 (3.6)	2	2	0	0
Heidelberg	4 (3.6)	3	1	0	0
Brandenburg	3 (2.7)	0	2	1	0
Mbandaka	3 (2.7)	1	2	0	0
Orion	3 (2.7)	3	0	0	0
Less common serovars	22 (20.0)	18	1	3	0
Total	**110 (100)**	**49**	**36**	**25**	**0**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

Abattoir Surveillance

(n = 105)

Recovery: *Salmonella* isolates were recovered from 35% (105/296) of pig cecal samples (Table B.4.3 in Appendix B).

Serovars: Results are presented in Table 18. The most common *Salmonella* serovars were Derby (17%, 18/105), Typhimurium (15%, 16/105), and Typhimurium var. 5- (15%, 16/105). These 3 serovars accounted for 48% (50/105) of all isolates.

Antimicrobial Resistance: Results are presented in Figure 24 and Table B.2.13 (Appendix B). One *Salmonella* isolate was resistant to amoxicillin-clavulanic acid and to ceftiofur. Intermediate susceptibility to ceftriaxone was detected in 1 isolate. None of the isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, nalidixic acid, or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 18. Resistance to 1 or more antimicrobials was detected in 62% (65/105) of *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 26% (27/105). The most common resistance patterns were ACSSuT (15%, 16/105), STR-SSS-TET (10%, 11/105), and tetracycline alone (10%, 11/105). Twenty-three percent (24/105) of isolates had the ACSSuT pattern, and 7% (7/105) had the ACKSSuT pattern.

The ACSSuT and ACKSSuT resistance patterns were detected mainly in isolates of *S.* Typhimurium (8/16 and 3/16, respectively) and *S.* Typhimurium var. 5- (9/16 and 1/16, respectively). The pattern involving resistance to the most antimicrobials was A2C-ACKSSuT, which was detected in 1 *Salmonella*. ssp. I 4,[5],12:i:- isolate.

Temporal variations: Results are presented in Figure 25. Percentages of isolates with resistance to ampicillin, gentamicin, and streptomycin were significantly higher in 2007 (29% [30/105], 6% [6/105], and 45% [47/105], respectively) than in 2003 (18% [69/391], 2% [7/391], and 34% [132/391], respectively). No other significant temporal variations were detected between 2007 and 2003.

In 2007, the percentages of *Salmonella* isolates from abattoir pig samples with resistance to ampicillin, gentamicin, and streptomycin were significantly higher in 2007 (29% [30/105], 6% [6/105], and 45% [47/105], respectively) than in 2003 (18% [69/391], 2% [7/391], and 34% [132/391], respectively).

Figure 24. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2007.

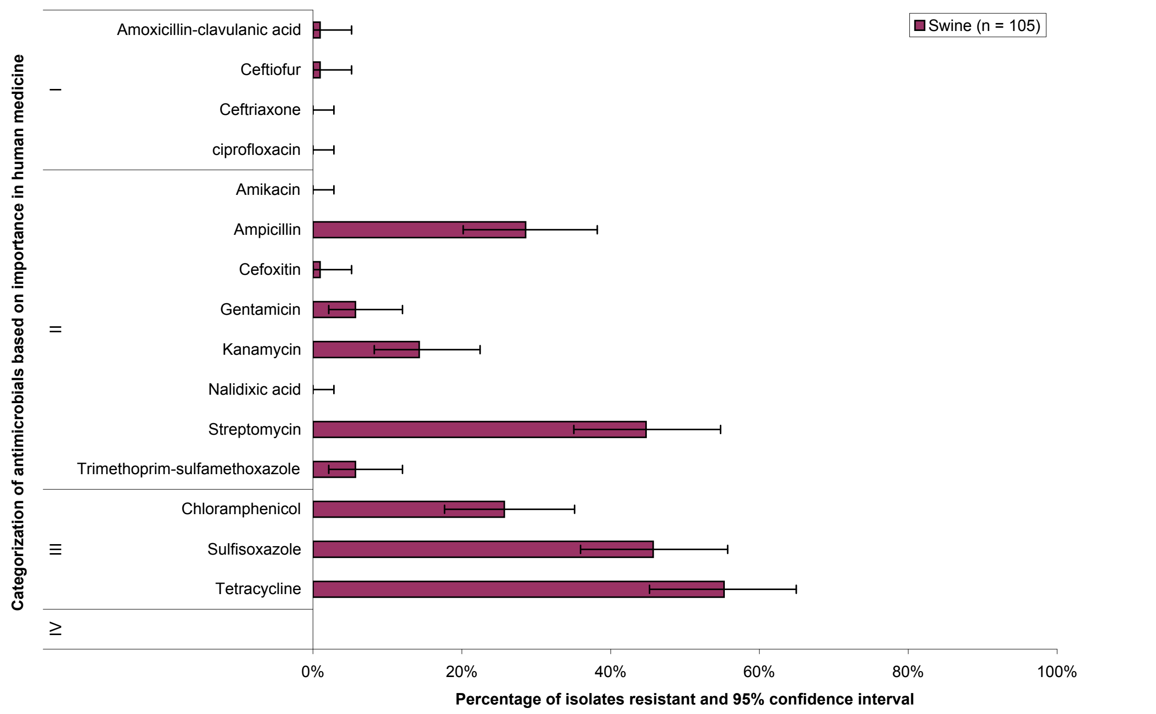
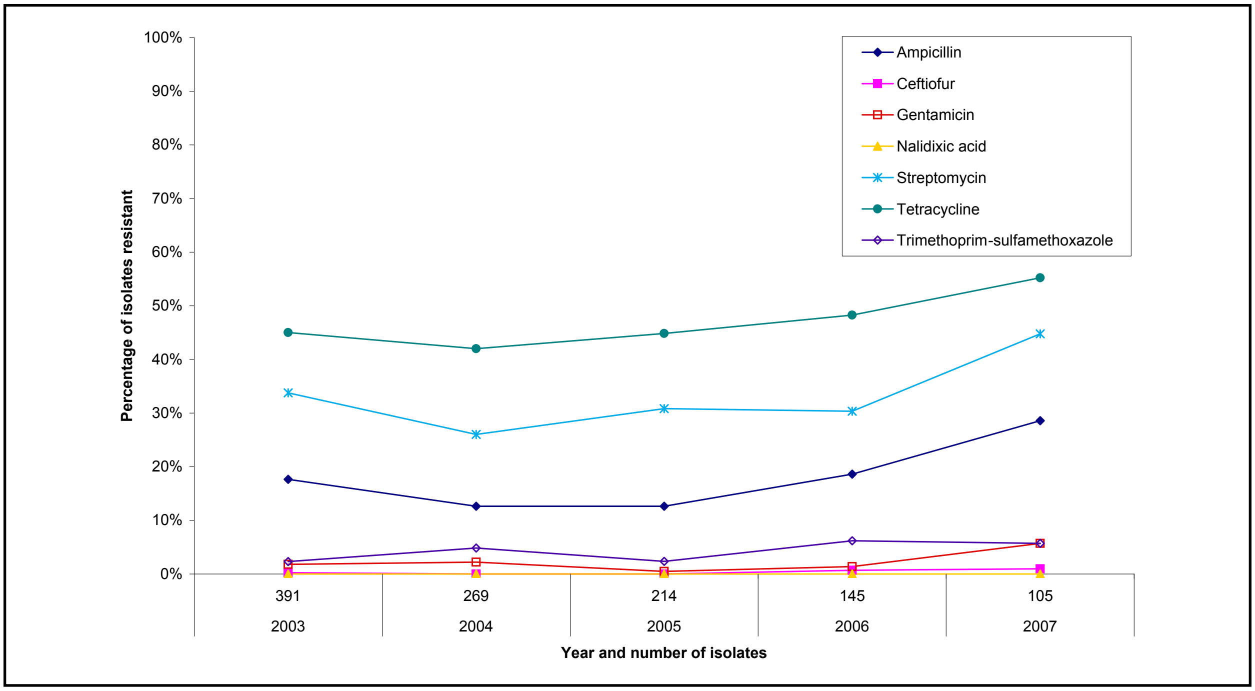


Table 18. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Abattoir Surveillance*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Derby	18 (17.1)	3	15	0	0
Typhimurium	16 (15.2)	3	1	12	0
Typhimurium var. 5-	16 (15.2)	1	5	10	0
Brandenburg	6 (5.7)	5	1	0	0
Infantis	6 (5.7)	5	1	0	0
London	5 (4.8)	5	0	0	0
Mbandaka	4 (3.8)	2	1	1	0
Agona	3 (2.9)	1	2	0	0
California	3 (2.9)	1	2	0	0
Heidelberg	3 (2.9)	0	3	0	0
Krefeld	3 (2.9)	1	2	0	0
Less common serovars	22 (21)	13	5	3	1
Total	**105 (100)**	**40**	**38**	**26**	**1**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Figure 25. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2003–2007.



Surveillance of Animal Clinical Isolates

(n = 187)

Serovars: Results are presented in Table 19. The most common *Salmonella* serovars in pig clinical isolates were Typhimurium (35%, 66/187), Typhimurium var. 5- (20%, 38/187), and Derby (13%, 25/187). These 3 serovars accounted for 69% (129/187) of *Salmonella* isolates.

Antimicrobial Resistance: Results are presented in Table B.2.14 (Appendix B). Resistance to amoxicillin-clavulanic acid and ceftiofur was detected in 2% (4/187) of *Salmonella* isolates. Intermediate susceptibility to ceftriaxone was detected in 2% (4/187). None of the isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, nalidixic acid, or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 19. Resistance to 1 or more antimicrobials was detected in 75% (141/187) of all *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 44% (82/187). The most common resistance patterns were ACSSuT (18%, 33/187), ACKSSuT (8%, 15/187), and ACKSSuT-SXT (6%, 11/187). Thirty-three percent (62/187), 14% (27/187), 20% (37/187), and 1% (2/187) of isolates had the ACSSuT, ACKSSuT, AKSSuT, and A2C-ACSSuT resistance patterns, respectively. One isolate had the A2C-AMP resistance pattern, and another had the A2C-ACKSSuT resistance pattern.

Sixty-six percent (25/38) of Typhimurium var. 5- isolates, 59% (39/66) of Typhimurium isolates, and 16% (4/25) of Derby isolates were resistant to 5 or more antimicrobials. The pattern involving resistance to most antimicrobials was A2C-ACKSSuT-GEN, which was detected in 1 *S.* Ohio isolate. This pattern (A2C-ACKSSuT-GEN) was also detected in 1 *S.* Ohio isolate in 2002, but with additional resistance to trimethoprim-sulfamethoxazole.

For 2007, resistance to ceftiofur (2%, 4/187) and intermediate susceptibility to ceftriaxone (2%, 4/187) was detected in clinical *Salmonella* isolates from pigs. Sixty-six percent (25/38) of *S.* Typhimurium var. 5- isolates, 59% (39/66) of *S.* Typhimurium isolates, and 16% (4/25) of *S.* Derby isolates were resistant to 5 or more antimicrobials. The pattern involving resistance to the most antimicrobials was A2C-ACKSSuT-GEN, which was detected in 1 *S.* Ohio isolate.

Table 19. Number of antimicrobials in resistance patterns of *Salmonella* isolates from pigs, by serovar; *Surveillance of Animal Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	66 (35.3)	6	21	39	0
Typhimurium var. 5-	38 (20.3)	2	11	25	0
Derby	25 (13.4)	9	12	4	0
Infantis	9 (4.8)	9	0	0	0
Brandenburg	6 (3.2)	3	2	1	0
Schwarzengrund	5 (2.7)	2	3	0	0
Mbandaka	4 (2.1)	1	2	1	0
Ohio	4 (2.1)	0	0	2	2
Less common serovars	30 (16)	14	8	7	1
Total	**187 (100)**	**46**	**59**	**79**	**3**

Serovars represented by less than 2% of isolates were classified as "Less common serovars."

Escherichia coli

Farm Surveillance

(n = 1,575)

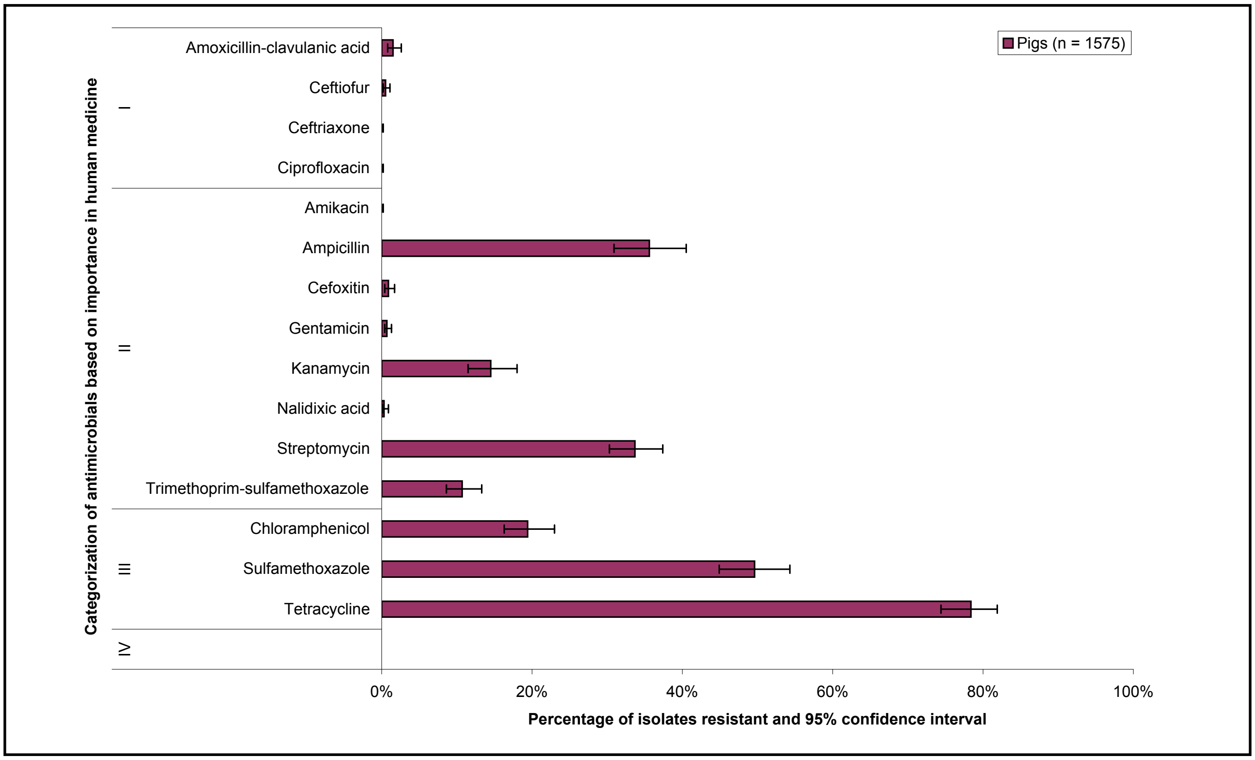
Recovery: *Escherichia coli* isolates were recovered from 100% (612/612) of fecal samples from pigs. Up to 3 isolates per positive specimen were kept for analysis.

Antimicrobial Resistance: Results are presented in Figure 26 and Table B.2.15 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 1% (22/1,575) of *E. coli* isolates. Ceftiofur resistance was detected in less than 1% (7/1,575). Three isolates had intermediate susceptibility to ceftriaxone, and no isolate had reduced susceptibility to ciprofloxacin. None of the isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 86% (1,356/1,575) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 12% (194/1,575). The most common resistance patterns were tetracycline alone (16%, 250/1,575), AMP-TET (5%, 84/1,575), and SSS-TET (5%, 80/1,575). Twenty-three percent (46/1,575) of isolates had the ACSSuT pattern, 2% (33/1,575) had the AKSSuT pattern, and less than 1% (14/1,575) had the ACKSSuT pattern.

In 2007, resistance to ceftiofur or amoxicillin-clavulanic acid was detected in 1% or less of the 1,575 *Escherichia coli* isolates from pig fecal samples. Three isolates had intermediate susceptibility to ceftriaxone, and no isolates had reduced susceptibility to ciprofloxacin. Eighty six percent (1,356/1,575) of isolates were resistant to one or more antimicrobials.

Figure 26. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance*, 2007.



Abattoir Surveillance

(n = 93)

Recovery: *Escherichia coli* isolates were recovered from 98% (93/95) of all pig caecal samples (Table B.4.3 in Appendix B).

Antimicrobial Resistance: Results are presented in Figure 27 and Table B.2.16 (Appendix B). One isolate of *E. coli* was resistant to amoxicillin-clavulanic acid and ceftiofur. None of the isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin, nalidixic acid, or had reduced susceptibility to ciprofloxacin or intermediate susceptibility to ceftriaxone.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 82% (76/93) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 12% (11/93). The most common resistance patterns were tetracycline alone (11%, 10/93), AMP-STR-TET (6%, 6/93), and SSS-TET (6%, 6/93). Five percent (5/93) and 3% (3/93) of isolates had the AKSSuT and ACSSuT resistance patterns, respectively. One isolate had the A2C-AMP resistance pattern, and another had the ACKSSuT resistance pattern.

Temporal variations: Results are presented in Figure 28. Between 2007 and 2003, no significant temporal variations were detected in the percentages of *E. coli* isolates with resistance to selected antimicrobials.

In 2007, resistance to amoxicillin-clavulanic acid, and ceftiofur was detected in 1 *Escherichia coli* isolates from abattoir pigs. Resistance to 1 or more antimicrobials was detected in 82% (76/93) of *E. coli* isolates. Resistance to 5 or more antimicrobials was detected in 12% (11/93) of isolates.

Figure 27. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2007.

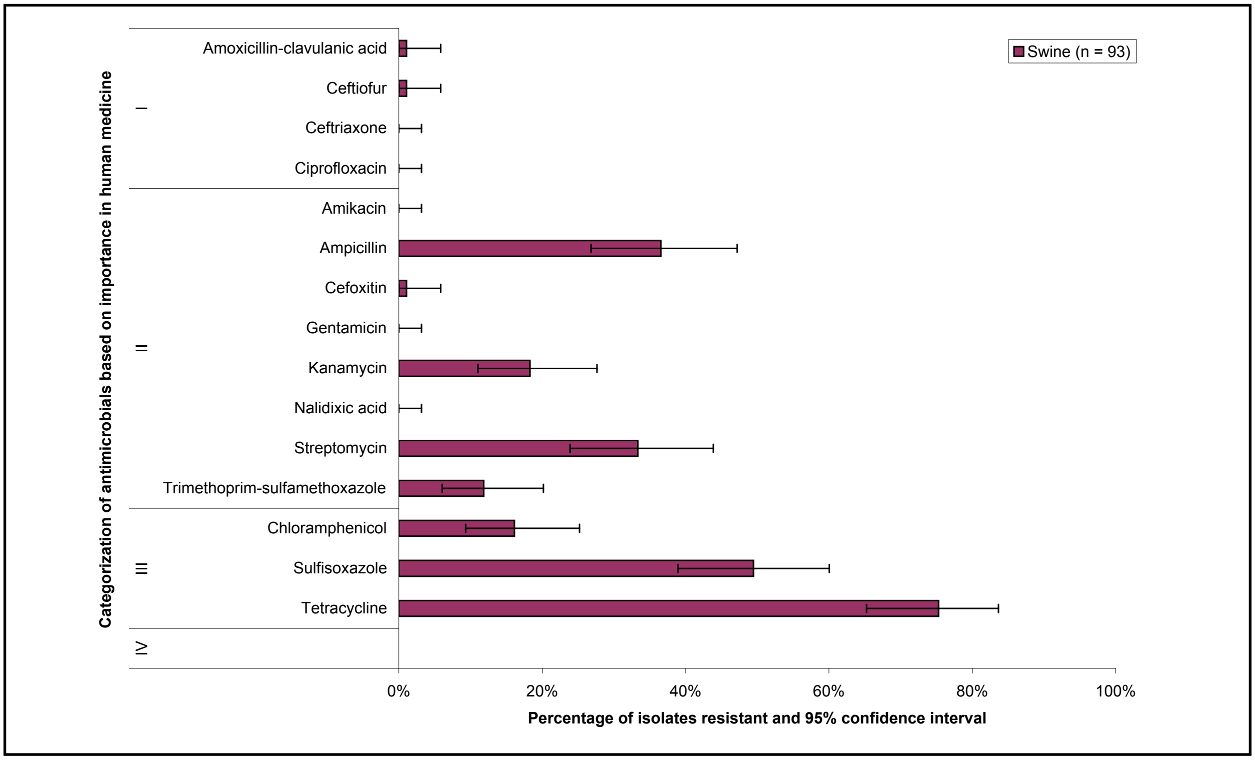
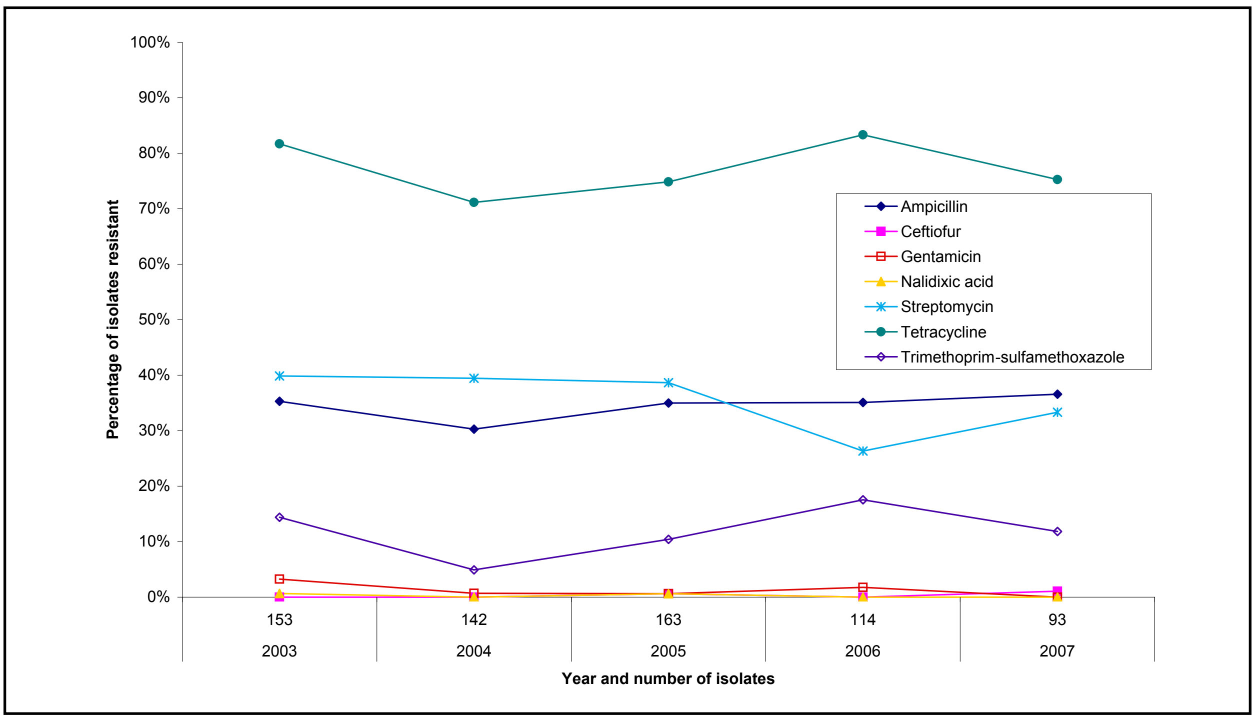


Figure 28. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2003–2007.



Retail Meat Surveillance

(n = 297)
(British Columbia, n = 23; Saskatchewan, n = 38; Ontario, n = 172; Québec, n = 64)

Recovery: *Escherichia coli* isolates were recovered from 35% (297/840) of all retail pork samples (Table B.4.3 in Appendix B). Province-specific percentages of pork samples from which isolates were recovered were as follows: British Columbia, 29% (23/79); Saskatchewan, 25% (38/154); Ontario, 54% (172/320); and Québec, 22% (64/287).

Antimicrobial Resistance: Results are presented in Figure 29 and Table B.2.17 (Appendix B). Resistance to amoxicillin-clavulanic acid was detected in 1 *E. coli* isolate from Saskatchewan and 2 isolates from Ontario. Resistance to ceftiofur was detected in 1 isolate from Saskatchewan and 1 isolate from Ontario. Resistance to ceftiofur and amoxicillin-clavulanic acid was not detected in any isolates from British Columbia or Québec. Intermediate susceptibility to ceftriaxone was not detected. Reduced susceptibility to ciprofloxacin was detected in 1 isolate from Ontario. There were no significant differences among the provinces in percentages of isolates with resistance to any of the antimicrobials. None of the isolates from any province were resistant to ceftriaxone or ciprofloxacin.

Antimicrobial Resistance Patterns: Resistance to 1 or more antimicrobials was detected in 35% (8/23) of *E. coli* isolates from British Columbia, 26% (10/38) of isolates from Saskatchewan, 50% (86/172) of isolates from Ontario, and 48% (31/64) of isolates from Québec. Resistance to 5 or more antimicrobials was detected in 1 isolate from Saskatchewan, 8% (14/172) of isolates from Ontario, and 5% (3/64) of isolates from Québec. Among the isolates from all 4 provinces, the most common resistance patterns were tetracycline alone (11%, 34/297) and AMP-STR-TET (4%, 13/297). The A2C-AMP pattern was detected in 2 isolates.

Temporal variations: Results are presented in Figure 30. Between 2003 and 2007, there were no significant temporal variations in percentages of *E. coli* isolates resistant to the tested antimicrobials for any province.

In 2007, isolates of *Escherichia coli* were recovered from a greater proportion of retail pork samples from Ontario than from British Columbia, Saskatchewan, or Québec. One isolate from Ontario had reduced susceptibility to ciprofloxacin. The A2C-AMP resistance pattern was detected in less than 1% (2/297) of isolates.

Figure 29. Resistance to antimicrobials in *Escherichia coli* isolates from pork, by province; *Retail Meat Surveillance*, 2007.

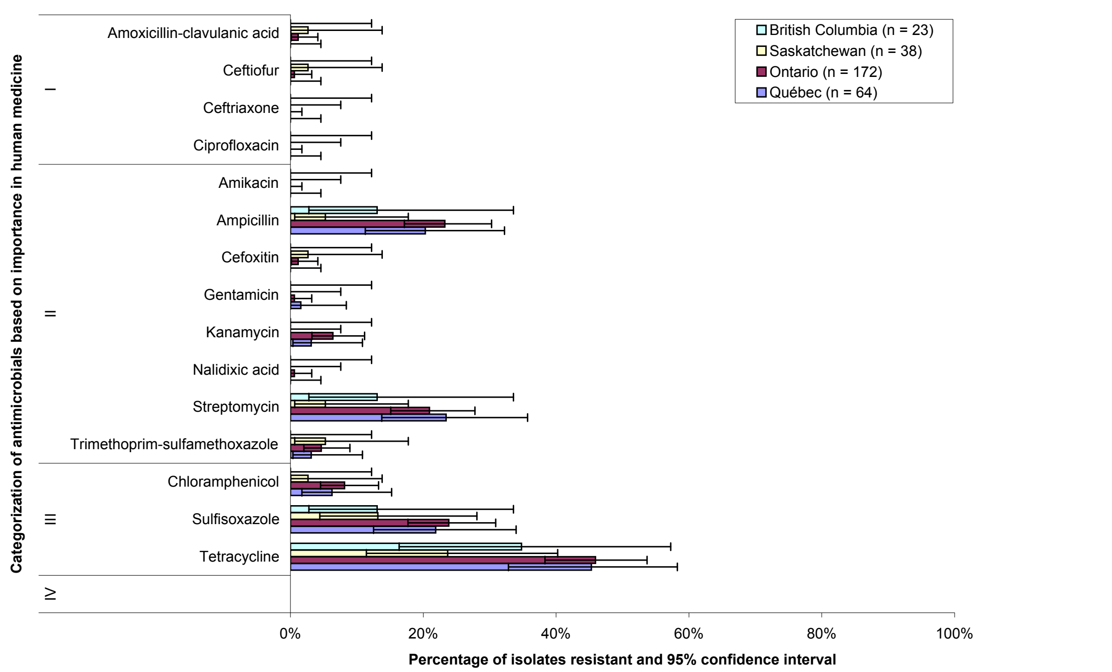
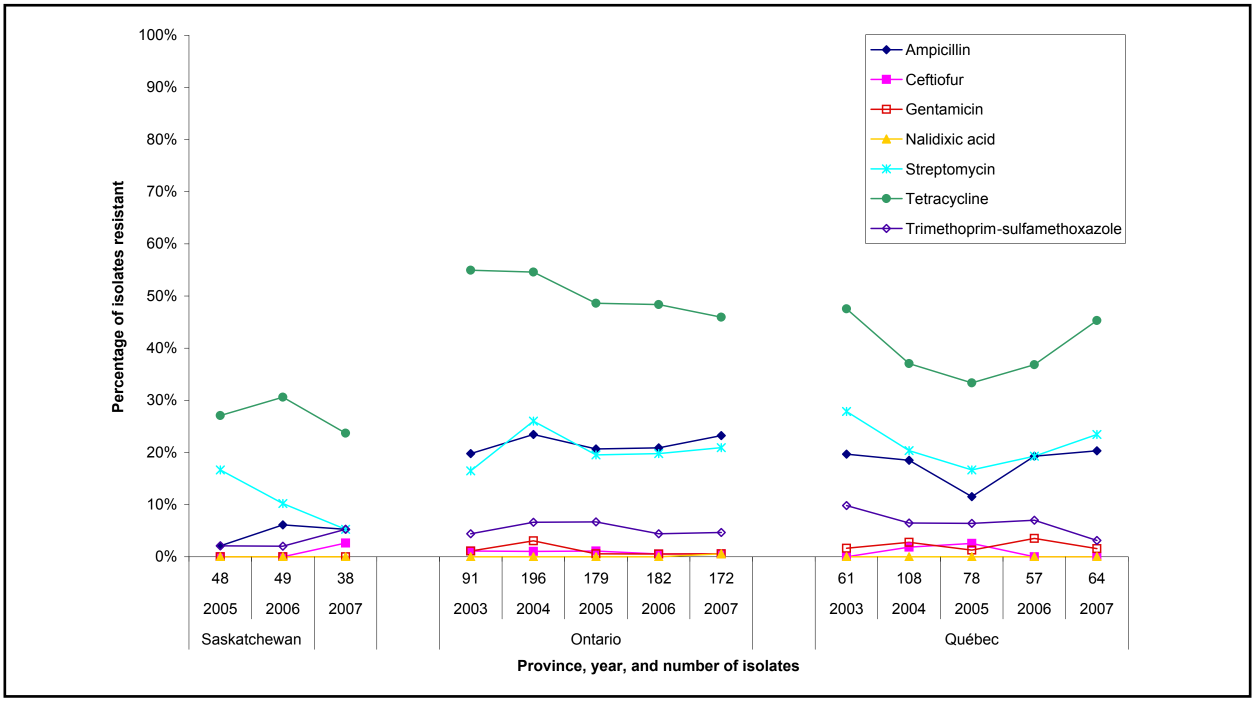


Figure 30. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pork; *Retail Meat Surveillance*, 2003–2007.



Enterococcus

Farm Surveillance
(n = 985)

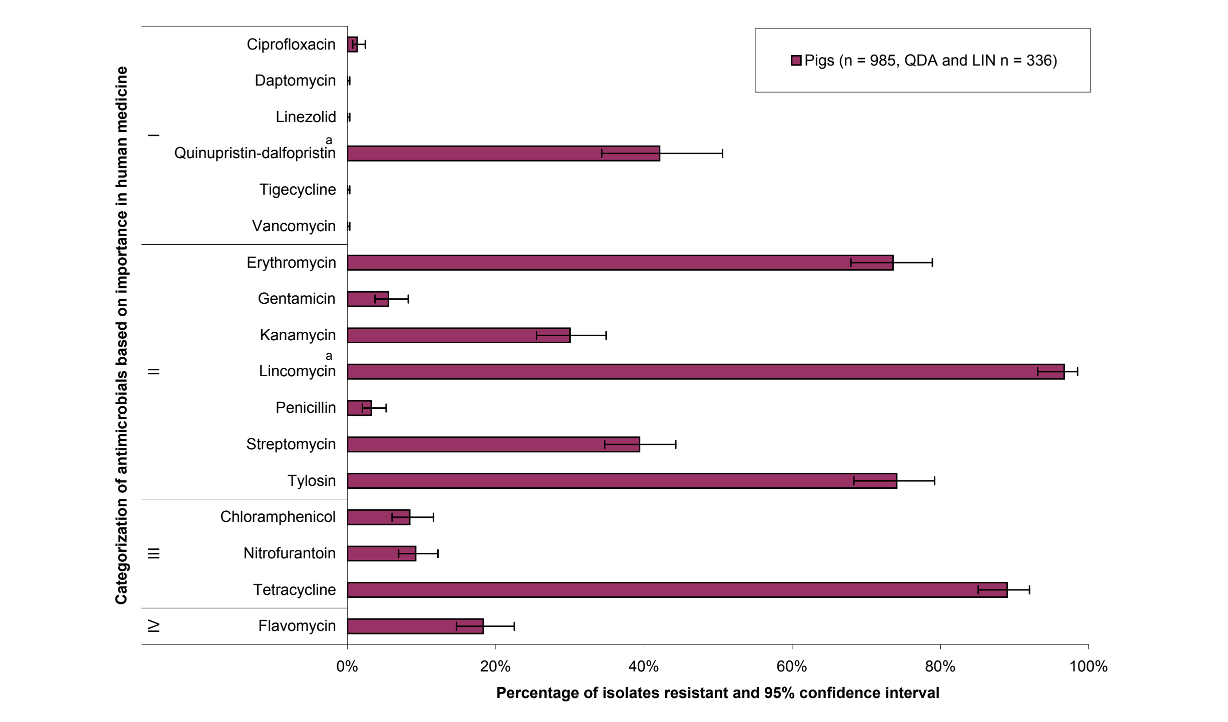
Recovery: *Enterococcus* isolates were recovered from 81% (494/612) of fecal samples from pigs. Up to 2 isolates per positive sample were kept for analysis. Sixty-six percent (649/985) of the isolates were *E. faecalis*, 30% (292/985) were other *Enterococcus* spp., and 4% (44/985) were *E. faecium*.

Antimicrobial Resistance: Results are presented in Figure 31 and Table B.2.18 (Appendix B). Ciprofloxacin resistance was detected in less than 1% (3/649) of *E. faecalis* isolates, in 16% (7/44) of *E. faecium* isolates, and in 1% (3/292) of other *Enterococcus* spp. isolates. Daptomycine non-susceptibility was detected in less than 1% (2/649) of *E. faecalis* isolates in 11%(5/44) of *E. faecium* isolates and in less than 1% (1/292) of other *Enterococcus* spp. isolates. Resistance to quinupristin-dalfopristin and ciprofloxacin was detected in 45% (150/336) and 1% (13/985) of *Enterococcus* isolates, respectively. The distribution of isolates with quinupristin-dalfopristin resistance was 27% (12/44) for *E. faecium* and 47% (138/292) for other *Enterococcus* spp. None of the isolates were resistant to linezolid, tigecycline, or vancomycin.

Antimicrobial Resistance Patterns: Results are presented in Table 20. Resistance to 1 or more antimicrobials was detected in 97% (951/985) of all *Enterococcus* isolates. Resistance to 5 or more antimicrobials was detected in 39% (387/985). The most common resistance patterns were ERY-TET-TYL (14%, 140/985), ERY-KAN-STR-TET-TYL (12%, 118/985), and tetracycline alone (8%, 83/985).

In 2007, none of the *Enterococcus* isolates recovered from pig fecal samples were resistant to linezolid, tigecycline, or vancomycin. Resistance to quinupristin-dalfopristin was detected in 45% (150/336) of non *faecalis* isolates.

Figure 31. Resistance to antimicrobials in *Enterococcus* isolates from pigs; *Farm Surveillance*, 2007.



[a] Resistance to quinupristin-dalfopristin (QDA) and lincomycin (LIN) is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Table 20. Number of antimicrobials in resistance patterns of *Enterococcus* isolates from pigs, by *Enterococcus* species; *Farm Surveillance*, 2007.

Species	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 17
		Number of isolates			
E. faecalis	649 (65.9)	34	420	195	0
E. faecium	44 (4.5)	0	30	14	0
Enterococcus spp.	292 (29.6)	0	114	168	10
Total	**985 (100)**	**34**	**564**	**377**	**10**

Turkeys

Salmonella

Surveillance of Animal Clinical Isolates

(n = 49)

Serovars: Results are presented in Table 21. The most common *Salmonella* serovars in turkey clinical isolates were Typhimurium (20%, 10/49), Heidelberg (16%, 8/49), and Senftenberg (14%, 7/49). These 3 serovars accounted for 51% (25/49) of all isolates.

Antimicrobial Resistance: Results are presented in Table B.2.19 (Appendix B). Resistance to amoxicillin-clavulanic acid, ceftiofur, and intermediate susceptibility to ceftriaxone were each detected in 49% (24/49) of *Salmonella* isolates. None of the isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, nalidixic acid, or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 21. Resistance to 1 or more antimicrobials was detected in 86% (42/49) of all *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 22% (11/49). The most common resistance patterns were A2C-AMP (27%, 13/49) and tetracycline alone (12%, 6/49). Four percent (2/49) and 2% (1/49) of isolates had the A2C-AKSSuT and A2C-ACSSuT resistance patterns, respectively.

Regarding specific *Salmonella* serovars, resistance to 5 or more antimicrobials was detected in 1 Typhimurium, 2 Heidelberg, and 4 Senftenberg isolates. The patterns involving resistance to the most antimicrobials were A2C-AKSSuT-GEN and A2C-ACSSuT-GEN, which were detected in 2 *S.* Bredeney isolates and 1 *S.* Senftenberg isolate, respectively.

In 2007, 49% (24/49) of turkey clinical isolates of *Salmonella* had resistance to amoxicillin-clavulanic acid, ceftiofur, and intermediate susceptibility to ceftriaxone. Resistance to 1 or more antimicrobials was detected in 86% (42/49) of all *Salmonella* isolates. The patterns involving resistance to the most antimicrobials were A2C-AKSSuT-GEN and A2C-ACSSuT-GEN, which were detected in 2 *S.* Bredeney isolates and 1 *S.* Senftenberg isolate, respectively.

Table 21. Number of antimicrobials in resistance patterns of *Salmonella* isolates from turkeys, by serovar; *Surveillance of Animal Clinical Isolates*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Typhimurium	10 (20.4)	0	9	1	0
Heidelberg	8 (16.3)	1	5	2	0
Senftenberg	7 (14.3)	1	2	3	1
Agona	5 (10.2)	0	3	2	0
Hadar	4 (8.2)	0	4	0	0
Anatum	2 (4.1)	0	2	0	0
Bredeney	2 (4.1)	0	0	0	2
Derby	2 (4.1)	0	2	0	0
Enteritidis	2 (4.1)	2	0	0	0
I:4,12:-:-	2 (4.1)	0	2	0	0
Albany	1 (2)	0	1	0	0
Brandenburg	1 (2)	1	0	0	0
I:Rough-O:eh:1,5	1 (2)	0	1	0	0
Thompson	1 (2)	1	0	0	0
Typhimurium var. 5-	1 (2)	1	0	0	0
Total	**49 (100)**	**7**	**31**	**8**	**3**

Horses

Salmonella

Surveillance of Animal Clinical Isolates

(n = 67)

Serovars: Results are presented in Table 22. The most common *Salmonella* serovars in horse clinical isolates were Heidelberg (82%, 55/67), Typhimurium (7%, 5/67), and Newport (3%, 2/67) and Rubislaw (3%, 2/67). These 4 serovars accounted for 94% (63/67) of all isolates.

Antimicrobial Resistance: Results are presented in Table B.2.20 (Appendix B). Resistance to ceftiofur was detected in 3% (2/67) of *Salmonella* isolates. Reduced susceptibility to ciprofloxacin was detected in 66% (44/67). None of the isolates were resistant to amoxicillin-clavulanic acid, ceftriaxone, ciprofloxacin, cefoxitin, nalidixic acid, or had intermediate susceptibility to ceftriaxone.

Antimicrobial Resistance Patterns: Results are presented in Table 22. Resistance to 1 or more antimicrobials was detected in 84% (56/67) of all *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 79% (53/67). The most common resistance patterns were AMP-CHL-GEN-KAN-SSS-SXT (45%, 30/67), AMP-GEN-KAN-SSS-SXT (18%, 12/67), and AMP-CHL-GEN-KAN-STR-SSS-SXT (7%, 5/67). One isolate had the ACSSuT resistance pattern, and another had the AKSSuT resistance pattern.

Regarding specific *Salmonella* serovars, resistance to 5 or more antimicrobials was detected in 94% (51/54) of Heidelberg isolates and 2 Typhimurium isolates. The patterns involving resistance to most antimicrobials were AMP-CHL-GEN-KAN-STR-SSS-SXT (5 *S.* Heidelberg isolates), AMP-TIO-CHL-GEN-KAN-SSS-SXT (2 *S.* Heidelberg isolates), and AKSSuT-GEN-SXT (1 *S.* Typhimurium isolate).

In 2007, reduced susceptibility to ciprofloxacin was detected in 66% (44/67) of horse clinical isolates of *Salmonella*. Resistance to 5 or more antimicrobials was detected in 94% (51/54) of *S.* Heidelberg isolates and 2 *S.* Typhimurium isolates.

Table 22. Number of antimicrobials in resistance patterns of *Salmonella* isolates from horses, by serovar; *Surveillance of Animal Clinical Isolates*, 2007.

Serovar	number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Heidelberg	54 (80.6)	0	3	51	0
Typhimurium	5 (7.5)	3	0	2	0
Newport	2 (3)	2	0	0	0
Rubislaw	2 (3)	2	0	0	0
Less common serovars	4 (6)	4	0	0	0
Total	**67 (100)**	**11**	**3**	**53**	**0**

Serovars represented by less than 2% of isolates were classified as “Less common serovars.”

Feed and Feed Ingredients

Salmonella

(n = 179)

Note: These data include those obtained from Government and Industry Monitoring Programs from 2001 through 2007. The isolates originated from samples of feed destined for consumption by various animal species (e.g. cattle, chicken, fish, and dogs). However, information about the intended use of the feed was missing for 95% (170/179) of the isolates.

Serovars: Results are presented in Table 23. The most common *Salmonella* serovars were Mbandaka (11%, 19/179), Tennessee (10%, 17/179), and Senftenberg (9%, 16/179). Serovars Enteritidis, Heidelberg, Newport, and Typhimurium accounted for 1% (1/179), 1% (2/179), 2% (4/179), and 1% (2/179) of all isolates, respectively.

Antimicrobial Resistance: Results are presented in Table B.2. 21 (Appendix B). Resistance to amoxicillin-clavulanic acid and to ceftiofur were each detected in 2% (3/179) of *Salmonella* isolates recovered from feed. Intermediate susceptibility to ceftriaxone was detected in 1% (2/179) of isolates. None of the isolates were resistant to ciprofloxacin, amikacin, nalidixic acid, or had reduced susceptibility to ciprofloxacin.

Antimicrobial Resistance Patterns: Results are presented in Table 23. Resistance to 1 or more antimicrobials was detected in 13% (24/179) of all *Salmonella* isolates. Resistance to 5 or more antimicrobials was detected in 1% (2/179), which included 1 isolate each of *S.* Newport and *S.* Typhimurium. The most common resistance patterns were streptomycin alone (4%, 7/179), STR-TET (3%, 6/179), STR-SSS-TET (2%, 3/179), and CHL-TET (1%, 2/179). Two percent (3/179) of isolates had the A2C-AMP resistance pattern.

Two of the isolates with the A2C-AMP resistance pattern were *S.* Typhimurium, and 1 was *S.* Newport. One of the *S.* Typhimurium isolates and the *S.* Newport isolate also had intermediate susceptibility to ceftriaxone. The pattern involving resistance to the most antimicrobials was A2C-AMP-CHL-STR-TET-SXT, which was detected in 1 isolate of *S.* Newport in 2002.

In 2007, resistance to 1 or more antimicrobials was detected in 6% (3/47) of feed isolates of *Salmonella*. Since 2001, the most common resistance pattern has been streptomycin alone (4%, 7/179). The pattern involving resistance to the most antimicrobials was A2C-AMP-CHL-STR-TET-SXT, which was detected in 1 *S.* Newport isolate in 2002.

Table 23. Number of antimicrobials in resistance patterns of feed *Salmonella* isolates from animal feed, by serovar; *Feed and Feed Ingredients*, 2007.

Serovar	Number (%) of isolates	Number of antimicrobials in resistance pattern			
		0	1 - 4	5 - 8	9 - 15
		Number of isolates			
Mbandaka	19 (10.6)	16	3	0	0
Tennessee	17 (9.5)	16	1	0	0
Senftenberg	16 (8.9)	13	3	0	0
Cubana	12 (6.7)	12	0	0	0
Brandenburg	11 (6.1)	11	0	0	0
Montevideo	11 (6.1)	11	0	0	0
Rissen	8 (4.5)	6	2	0	0
Anatum	7 (3.9)	1	6	0	0
Orion var.15+34+	6 (3.4)	6	0	0	0
Johannesburg	5 (2.8)	5	0	0	0
Oranienburg	5 (2.8)	5	0	0	0
I Rough:-:-	4 (2.2)	4	0	0	0
Newport	4 (2.2)	2	1	0	1
Less common serovars	54 (30.2)	47	6	1	0
Total	**179 (100)**	**155**	**22**	**1**	**1**

Serovars represented by less than 2% of isolates were classified as "less common serovars".

Section Two - Antimicrobial Use

Humans

For the CIPARS analysis of antimicrobial use in humans, data were obtained from the Canadian CompuScript (CCS) dataset provided by Intercontinental Medical Statistics (IMS) Health for 2000 through 2007. This dataset provides information on prescriptions dispensed by Canadian retail pharmacies. Additional information on IMS Health data collection and CIPARS analytic methods are described in Appendix A.5.

Canada Overall

In 2007, there were decreases in the antimicrobial prescription dispensing rate (Table 24 and Figure 32) and numbers of defined daily doses (DDDs)/1,000 inhabitant-days (Table 25, and Figure 34). The decreases, although modest (705 prescriptions/1,000 inhabitant-years in 2005, 715 in 2006, and 677 in 2007), brought the prescription rate and number of DDDs/1,000 inhabitant-days down to the levels observed in 2004. Expenditures decreased to the lowest level observed during the 8-year surveillance period (Table 26 and Figure 32). However, expenditures related to glycopeptides, linezolid, nitrofuran derivatives, and lincosamides continued to increase.

The 4 most commonly dispensed systemic antimicrobial classes in DDDs/1,000 inhabitant-days in 2007 were: extended-spectrum penicillins (4.42); macrolides (3.75); tetracyclines (2.37); and fluoroquinolones (2.09; Table 25). The consumption[18] of drugs in most classes decreased or remained stable between 2000 and 2007. During this period, increases in DDDs/1,000 inhabitant-days were observed for combinations of penicillins, including ß-lactamase inhibitors (amoxicillin-clavulanic acid: from 0.51 to 0.67), lincosamides (clindamycin: from 0.24 to 0.37), and nitrofuran derivatives (nitrofurantoin: from 0.42 to 0.58). Although increases in consumption of fluoroquinolones, macrolides, and first-generation cephalosporins were observed in 2006, small decreases in DDDs/1,000 inhabitant-days from 2006 to 2007 were present: from 2.14 to 2.09, 3.86 to 3.75, and 1.00 to 0.97, respectively. Category I antimicrobials continued to represent a high proportion (17%) of the total DDDs dispensed during 2007 (Figure 33).

Overall consumption of macrolides decreased in 2007 as consumption of erythromycin in DDDs/1,000 inhabitant-days continued to decrease from 0.33 in 2006 to 0.25 in 2007, with additional decreases observed for azithromycin (from 0.83 in 2006 to 0.78 in 2007) and telithromycin (from 0.06 in 2006 to 0.01 in 2007). Consumption of clarithromycin continued to increase from 2.48 in 2005 to 2.64 in 2006 to 2.68 in 2007 (Figure 35).

Although a decrease in consumption of fluoroquinolones was observed in 2007, the total DDDs/1,000 inhabitant-days for ciprofloxacin remained stable, whereas consumption of moxifloxacin continued to increase from 0.32 in 2005 to 0.40 in 2006 to 0.43 in 2007. During this period, there was a decrease in the use of levofloxacin, norfloxacin, ofloxacin, and gatifloxacin (Figure 36).

Provincial Variations

In 2007, differences in the total consumption of antimicrobials in DDDs (per 1,000 inhabitant-days) and total cost in dollars (per 1,000 inhabitant-days) were observed across Canada (Table 27 and Figure 37). Consumption and total cost were highest in Newfoundland and Labrador (29.83 DDDs and $81.47); whereas Québec had the lowest overall antimicrobial consumption (13.48 DDDs) and British Columbia had the lowest total cost ($50.12). Much of the inter-provincial variation in DDDs could be explained by differences in consumption of fluoroquinolones, first-generation cephalosporins, extended-spectrum penicillins, combinations of sulfonamides and trimethoprim (including derivatives), tetracyclines, and macrolides (Figure 36).

Newfoundland and Labrador continued to have the highest level of fluoroquinolone consumption in Canada (Table 27), which was influenced by the high levels of ciprofloxacin consumption (3.24 DDDs in 2005 to 3.51 DDDs

[18] Defined daily dosages were computed from dispensed prescription data for orally administered antimicrobials. However, an unknown proportion of the drugs sold by retail pharmacies is not consumed. To improve text clarity, the word "consumption" is used, although the total DDD estimates presented slightly overestimate true consumption.

in 2007[19]; Figure 38). As mentioned previously, consumption of moxifloxacin has been increasing since 2000, with Québec reporting the highest increase in the level of consumption, from 0.01 DDDs in 2000 to 0.61 DDDs in 2007 (Figure 39).

Saskatchewan had the second highest total consumption of antimicrobials, driven by higher consumption of antimicrobials belonging to classes of tetracyclines, first-generation cephalosporins, and nitrofuran derivatives (Table 27). The higher consumption of tetracyclines was attributable to an increase in consumption of doxycycline. Total doxycycline consumption increased from 2.29 DDDs in 2000 to 3.28 DDDs in 2007 (Figure 40). Among the other provinces, Alberta had the highest consumption of minocycline (1.61 DDDs), whereas Prince Edward Island had the highest consumption of tetracycline (1.35 DDDs).

In Saskatchewan, higher consumption of first-generation cephalosporins was influenced by levels of consumption of cephalexin (1.97 DDDs), compared with Québec, which reported the lowest consumption of cephalexin (0.26 DDDs). However, since 2000, consumption of cefadroxil has been much higher in Québec than in the other provinces. It continued to increase to its highest level in 2007 (0.14 DDDs), compared with consumption in 2000 (0.07 DDDs; Figure 41).

Consumption of third-generation cephalosporins remained stable through the past few years across Canada, with a small seasonal increase in consumption observed during the first quarter of every year. However, in the first quarter of 2007, a sharp increase in consumption was observed in Prince Edward Island: from 0.17 DDDs in the fourth quarter of 2006 to 0.48 DDDs in the first quarter of 2007, down to 0.24 DDDs in the second quarter of 2007 (Figure 42). The increase was driven by an increase in consumption of cefixime.

As mentioned previously, lincosamide consumption, particularly consumption of clindamycin, has continued to increase since 2000. During the 8-year period, the province of Alberta had the highest levels of consumption. Toward the later half of 2007, an increase in consumption was observed in Saskatchewan, making consumption of clindamycin in that province slightly higher than consumption in Alberta during that same period (0.48 versus 0.47 DDDs, respectively; Figure 43).

International Comparisons

The estimate of the total amount of oral antimicrobials dispensed in 2006 by Canadian retail pharmacies was compared with the total amount of outpatient antimicrobial use in 25 European countries[20] in the same year (Figure 44). This comparison showed that the level of consumption in Canada was similar to the level of consumption in Spain, Lithuania, and Bulgaria. Canada's oral antimicrobial consumption represented approximately twice the level of antimicrobial consumption reported by the Russian Federation (the country with the lowest level of consumption) and half the level estimated in Greece (the country with the highest level of consumption). Whereas Canada ranked 13th out of the 25 countries classified by increasing level of total antimicrobial consumption, it ranked 23rd for its level of consumption of macrolides and lincosamides, and 19th for its level of consumption of quinolones (largely consisting of fluoroquinolones). Canada was among the top 5 countries with the lowest level of penicillin consumption.

There was an overall decrease in prescribing and in DDDs/1000 inhabitant days since the beginning of CIPARS monitoring in 2000. However, Category I antimicrobials continued to represent a high proportion (17.0%) of the total DDDs dispensed during 2007. Consumption of fluoroquinolones has increased since 2000, despite a small decrease in consumption between 2006 and 2007. In 2007 antimicrobial consumption was highest in Newfoundland and Labrador (29.83 DDDs) and lowest in Québec (13.48 DDDs). Much of the inter-provincial variation in DDDs was explained by differences in consumption of fluoroquinolones, first-generation cephalosporins, extended-spectrum penicillins, combinations of sulfonamides and trimethoprim (including derivatives), tetracyclines, and macrolides.

[19] For the provinces of Newfoundland and Labrador and Prince Edward Island, comparisons were made with data reported for 2005 because prior to 2005, data from these provinces were combined.

[20] ESAC, 2009. ESAC – European Surveillance of Antimicrobial Consumption ESAC Yearbook 2006. Available at: http://www.esac.ua.ac.be/main.aspx?c=*ESAC2&n=50036. Accessed June 2009.

Table 24. Total number of prescriptions of oral antimicrobials dispensed by retail pharmacies per 1,000 inhabitants, 2000–2007.

ATC Class			Number of prescriptions/1,000 inhabitants							
			2000	2001	2002	2003	2004	2005	2006	2007
I	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	18.66	18.41	17.54	17.69	16.98	18.66	19.38	19.70
I	J01DD	Third-generation cephalosporins	5.66	5.28	4.83	4.23	3.68	3.74	3.78	3.99
I	J01MA	Fluoroquinolones	76.23	81.03	85.73	91.74	94.22	95.30	98.77	97.50
I	J01XA	Glycopeptides	0.14	0.14	0.16	0.19	0.34	0.39	0.38	0.41
I	J01XD	Imidazole	NA	16.65	16.71	17.09	17.25	17.41	18.51	17.70
I	J01XX	Linezolid	NA	< 0.01	0.01	0.02	0.04	0.04	0.05	0.05
II	J01CA	Penicillins with extended spectrum	193.18	183.54	171.05	169.81	156.08	168.34	168.98	158.55
II	J01CE	ß-lactamase sensitive penicillins	45.42	42.10	39.85	39.62	36.59	36.89	37.26	34.89
II	J01CF	ß-lactamase resistant penicillins	19.78	18.38	16.78	15.61	14.17	12.49	11.89	10.35
II	J01DB	First-generation cephalosporins	41.03	41.70	43.07	45.23	45.65	48.36	51.51	49.96
II	J01DC	Second-generation cephalosporins	55.09	48.95	43.06	41.41	39.37	39.65	37.43	32.68
II	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	56.52	50.62	44.56	41.05	37.12	35.15	35.47	33.63
II	J01FA	Macrolides	146.55	149.72	145.48	149.00	138.51	149.25	147.00	134.76
II	J01FF	Lincosamides	15.92	16.74	17.63	18.48	18.85	19.73	21.89	21.97
II	J01GB	Aminoglycosides	0.06	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01
II	J01MB	Other quinolones, excluding fluoroquinolones	0.08	0.06	0.05	0.04	0.05	< 0.01	< 0.01	< 0.01
II	J01RA	Sulfonamide combinations, excluding trimethoprim	3.50	2.43	1.58	1.05	0.67	0.60	0.52	0.36
II	J01XC	Steroid antimicrobials	0.06	0.06	0.05	0.05	0.05	0.06	0.07	0.05
III	J01AA	Tetracyclines	43.47	41.16	39.31	38.41	36.71	36.33	37.01	35.29
III	J01BA	Amphenicols	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	NA	NA
III	J01EA	Trimethoprim, including derivatives	2.22	2.12	2.13	2.16	2.02	1.85	1.96	1.93
III	J01EB	Short-acting sulfonamides	0.07	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
III	J01EC	Intermediate-acting sulfonamides	0.02	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
III	J01XE	Nitrofuran derivatives	14.61	15.76	16.41	17.48	19.13	20.35	22.70	23.16
III	J01XX	Fosfomycin	0.44	0.47	0.29	0.21	0.14	0.11	0.09	0.05
NC	J01XX	Methenamine	0.27	0.28	0.29	0.28	0.25	0.23	0.23	0.23
	J01	**Total**	**738.98**	**735.62**	**706.57**	**710.89**	**677.86**	**704.95**	**714.86**	**677.21**

Roman numerals I to III indicated the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NC = Not classified. NA = Not available.

Figure 32. Total number of prescriptions and total cost per 1,000 inhabitants for oral antimicrobials dispensed by retail pharmacies in Canada, 2000–2007.

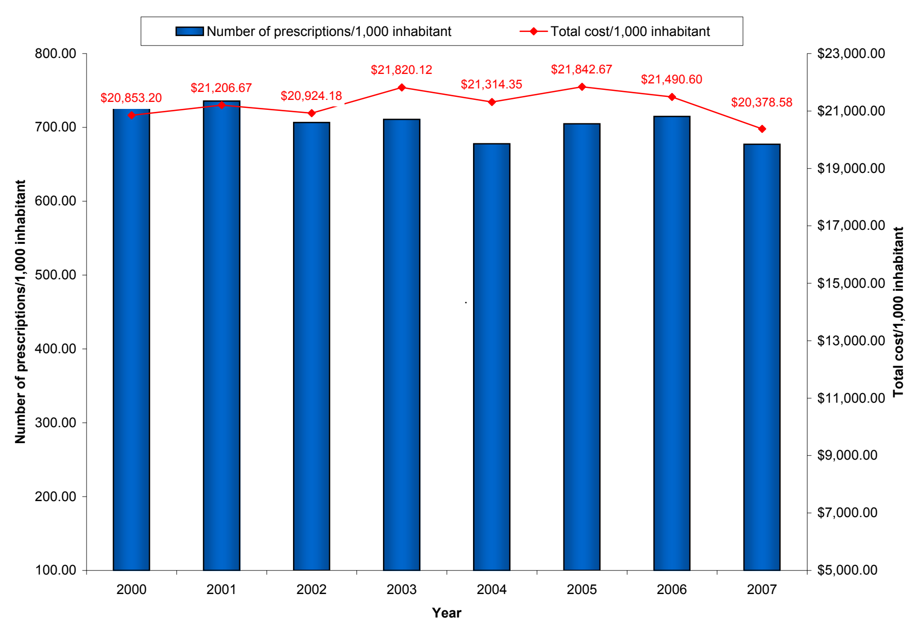


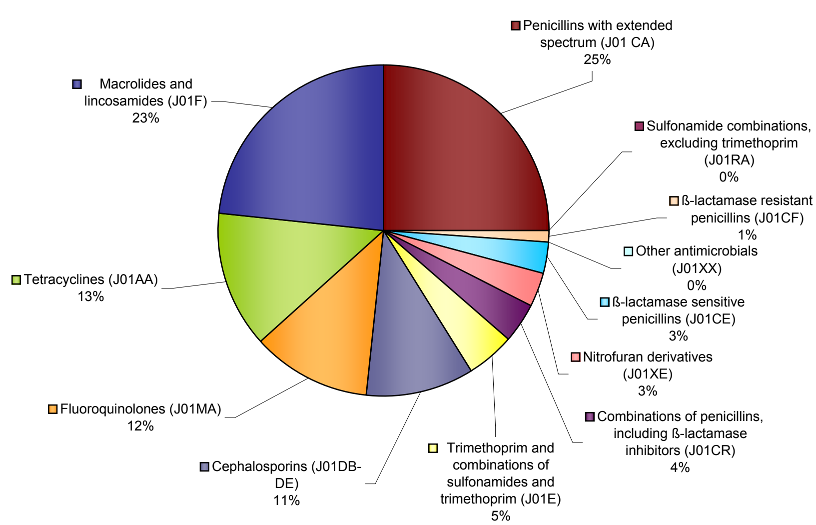
Table 25. Defined daily doses (DDDs) per 1,000 inhabitant-days for oral antimicrobials dispensed by retail pharmacies in Canada, 2000–2007.

ATC Class		DDDs/1,000 inhabitant-days							
		2000	2001	2002	2003	2004	2005	2006	2007
J01CR	Combinations of penicillins, including ß-lactamase inhibitors	0.51	0.52	0.50	0.52	0.52	0.59	0.64	0.67
J01DD	Third-generation cephalosporins	0.10	0.09	0.08	0.07	0.06	0.06	0.06	0.06
J01MA	Fluoroquinolones	1.83	1.93	1.99	2.08	2.09	2.08	2.14	2.09
J01XA	Glycopeptides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01XD	Imidazole	NA	0.21	0.22	0.22	0.22	0.23	0.24	0.23
J01XX	Linezolid	NA	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01CA	Penicillins with extended spectrum	5.07	4.90	4.63	4.57	4.38	4.52	4.61	4.42
J01CE	ß-lactamase sensitive penicillins	0.67	0.63	0.60	0.60	0.55	0.56	0.57	0.54
J01CF	ß-lactamase resistant penicillins	0.37	0.35	0.32	0.31	0.28	0.25	0.24	0.21
J01DB	First-generation cephalosporins	0.75	0.77	0.80	0.85	0.87	0.92	1.00	0.97
J01DC	Second-generation cephalosporins	1.39	1.22	1.05	1.00	0.94	0.96	0.91	0.83
J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	1.39	1.25	1.12	1.04	0.92	0.84	0.84	0.78
J01FA	Macrolides	3.64	3.62	3.42	3.57	3.43	3.77	3.86	3.75
J01FF	Lincosamides	0.24	0.27	0.28	0.31	0.32	0.32	0.36	0.37
J01GB	Aminoglycosides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01
J01MB	Other quinolones, excluding fluoroquinolones	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01RA	Sulfonamide combinations, excluding trimethoprim	0.03	0.02	0.01	0.01	0.01	0.01	< 0.01	< 0.01
J01XC	Steroid antimicrobials	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01AA	Tetracyclines	2.72	2.62	2.54	2.50	2.40	2.42	2.47	2.37
J01BA	Amphenicols	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	NA	NA
J01EA	Trimethoprim, including derivatives	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.05
J01EB	Short-acting sulfonamides	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01EC	Intermediate-acting sulfonamides	< 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	0.52	0.57	0.58
J01XX	Fosfomycin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
J01XX	Methenamine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
J01	**Total**	**19.23**	**18.93**	**18.11**	**18.21**	**17.58**	**18.13**	**18.58**	**17.95**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified.

Figure 33. Percentages of total number of defined daily doses (DDDs) per 1,000 inhabitant-days for oral antimicrobials dispensed by retail pharmacies in Canada, 2007.



Alphanumeric codes in parentheses represents Anatomical Therapeutic Chemical classes of antimicrobials.

Figure 34. Temporal trends in percentages of total numbers of defined daily doses (DDDs) per 1,000 inhabitant-days for oral antimicrobials dispensed by retail pharmacies in Canada, 2000–2007.

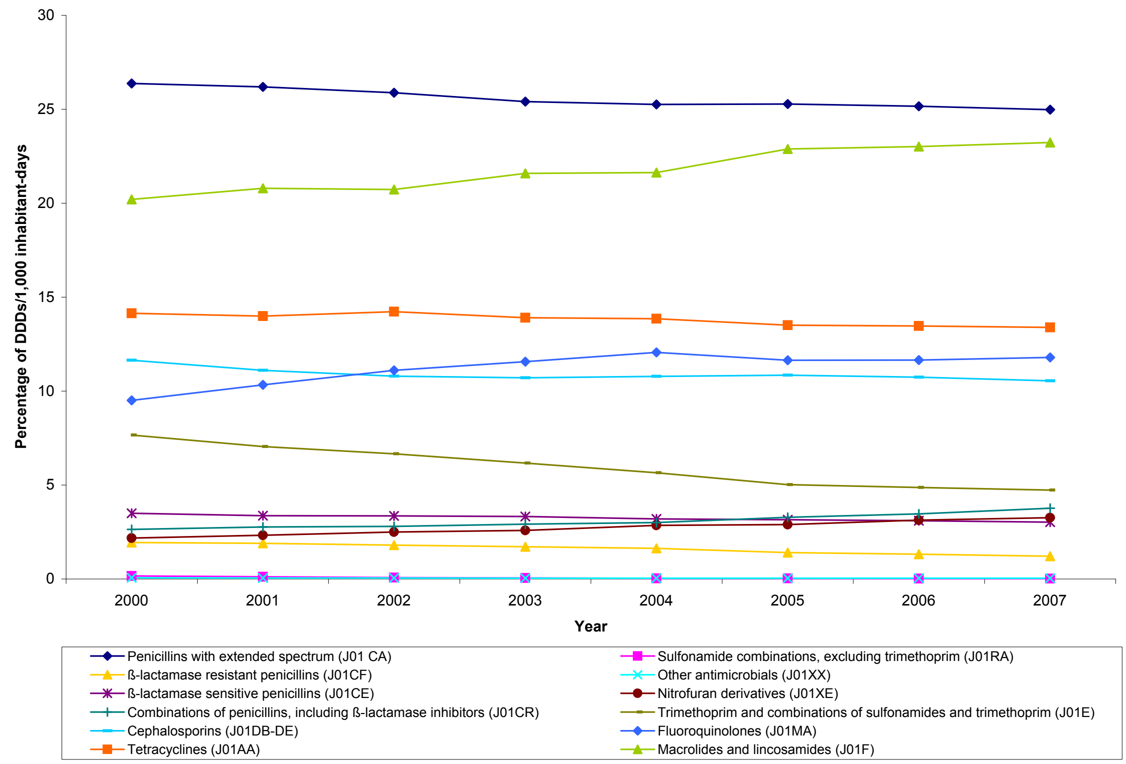


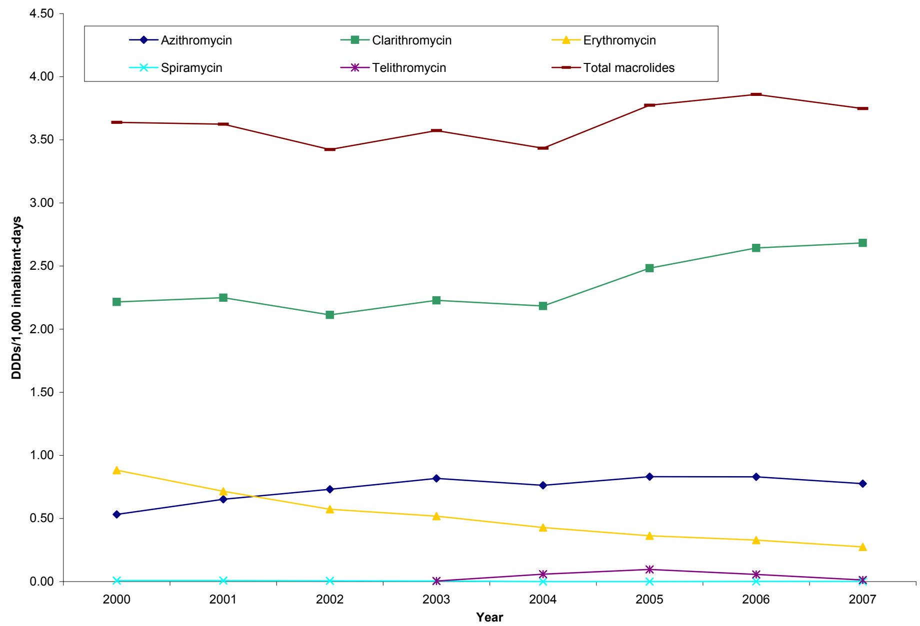
Table 26. Total cost per 1,000 inhabitants for oral antimicrobials dispensed by retail pharmacies in Canada, 2000−2007.

	ATC Class		Total cost/1,000 inhabitants ($)							
			2000	2001	2002	2003	2004	2005	2006	2007
	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	758.68	741.82	644.84	632.84	584.65	631.09	663.15	670.56
	J01DD	Third-generation cephalosporins	212.26	196.78	179.57	155.33	133.22	137.49	136.27	147.62
I	J01MA	Fluoroquinolones	4,285.71	4,555.96	4,758.29	5,078.69	4,859.20	4,280.24	4,176.95	4,186.70
	J01XA	Glycopeptides	51.03	54.88	62.08	76.38	131.23	148.95	145.53	159.22
	J01XD	Imidazole	NA	198.89	224.55	243.26	261.21	268.74	295.81	282.05
	J01XX	Linezolid	NA	6.36	19.53	43.61	71.59	95.82	91.62	98.97
	J01CA	Penicillins with extended spectrum	2,662.57	2,559.11	2,416.25	2,456.31	2,295.16	2,452.44	2,471.71	2,388.21
	J01CE	ß-lactamase sensitive penicillins	497.32	467.30	452.74	463.27	435.95	432.11	438.39	420.95
	J01CF	ß-lactamase resistant penicillins	287.70	272.68	251.58	242.19	226.14	197.11	189.04	168.97
	J01DB	First-generation cephalosporins	736.71	756.44	798.94	863.21	890.36	933.03	1,000.28	980.14
	J01DC	Second-generation cephalosporins	2,335.89	2,134.36	1,820.11	1,807.37	1,797.76	1,851.94	1,815.35	1,540.74
II	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	632.11	571.05	511.01	481.11	438.79	407.76	412.08	398.12
	J01FA	Macrolides	5,800.28	6,177.44	6,219.24	6,639.65	6,521.81	7,292.34	6,782.48	6,102.54
	J01FF	Lincosamides	666.80	605.60	635.04	654.75	675.26	698.80	773.51	781.40
	J01GB	Aminoglycosides	0.93	0.02	< 0.01	< 0.01	< 0.01	NA	< 0.01	0.01
	J01MB	Other quinolones, excluding fluoroquinolones	3.62	3.01	2.53	2.27	2.16	0.07	0.02	< 0.01
	J01RA	Sulfonamide combinations, excluding trimethoprim	95.14	66.22	43.47	29.38	19.60	18.21	15.81	11.31
	J01XC	Steroid antimicrobials	6.14	6.74	6.04	6.30	6.24	6.94	7.21	5.58
	J01AA	Tetracyclines	1,456.11	1,451.83	1,485.89	1,524.95	1,512.46	1,516.34	1,548.07	1,492.19
	J01BA	Amphenicols	0.02	0.05	0.01	NA	< 0.01	< 0.01	NA	NA
	J01EA	Trimethoprim, including derivatives	47.67	43.68	41.75	39.62	35.03	31.60	32.45	31.43
III	J01EB	Short-acting sulfonamides	2.79	0.35	0.03	0.02	0.02	< 0.01	0.01	< 0.01
	J01EC	Intermediate-acting sulfonamides	0.45	0.40	0.32	0.48	0.22	0.17	0.16	0.18
	J01XE	Nitrofuran derivatives	290.94	312.33	332.83	364.93	404.48	431.71	485.87	504.05
	J01XX	Fosfomycin	14.71	16.06	10.39	7.60	5.52	4.43	3.59	2.11
NC	J01XX	Methenamine	7.64	7.27	7.14	6.59	6.31	5.34	5.23	5.51
	J01	**Total**	**20,853.20**	**21,206.67**	**20,924.18**	**21,820.12**	**21,314.35**	**21,842.67**	**21,490.60**	**20,378.58**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

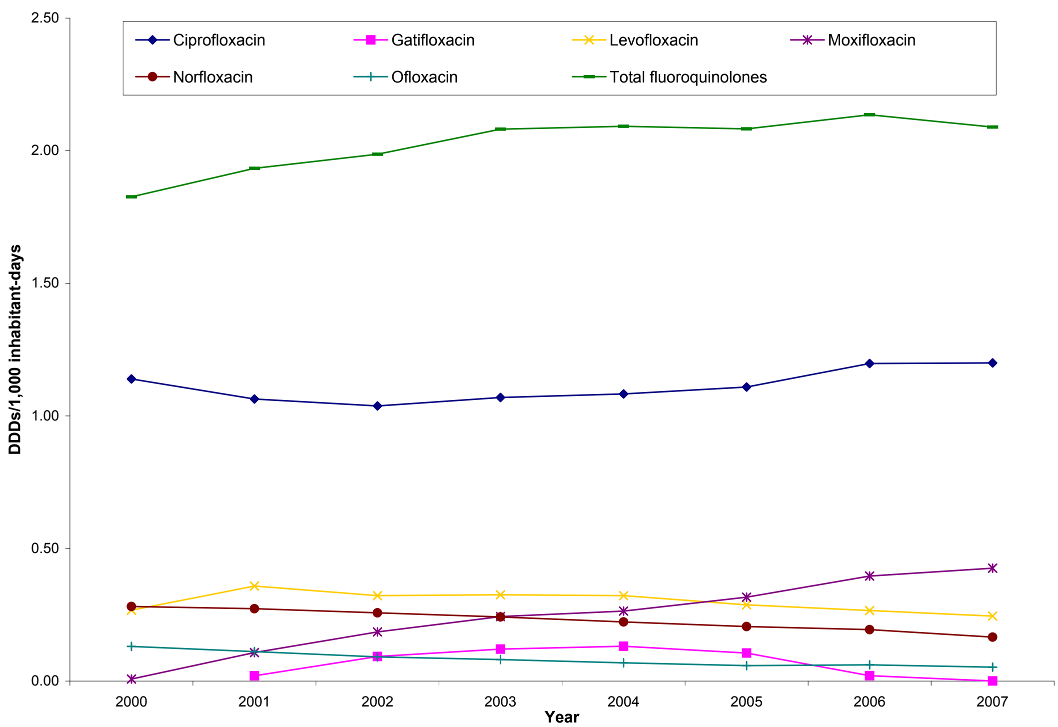
ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified.

Figure 35. Total consumption of oral macrolides (DDDs/1,000 inhabitant-days) dispensed by retail pharmacies in Canada, 2000–2007.



DDD = Defined daily dose.

Figure 36. Total consumption (DDDs/1,000 inhabitant-days) of oral fluoroquinolones dispensed by retail pharmacies in Canada, 2000–2007.



DDD = Defined daily dose.

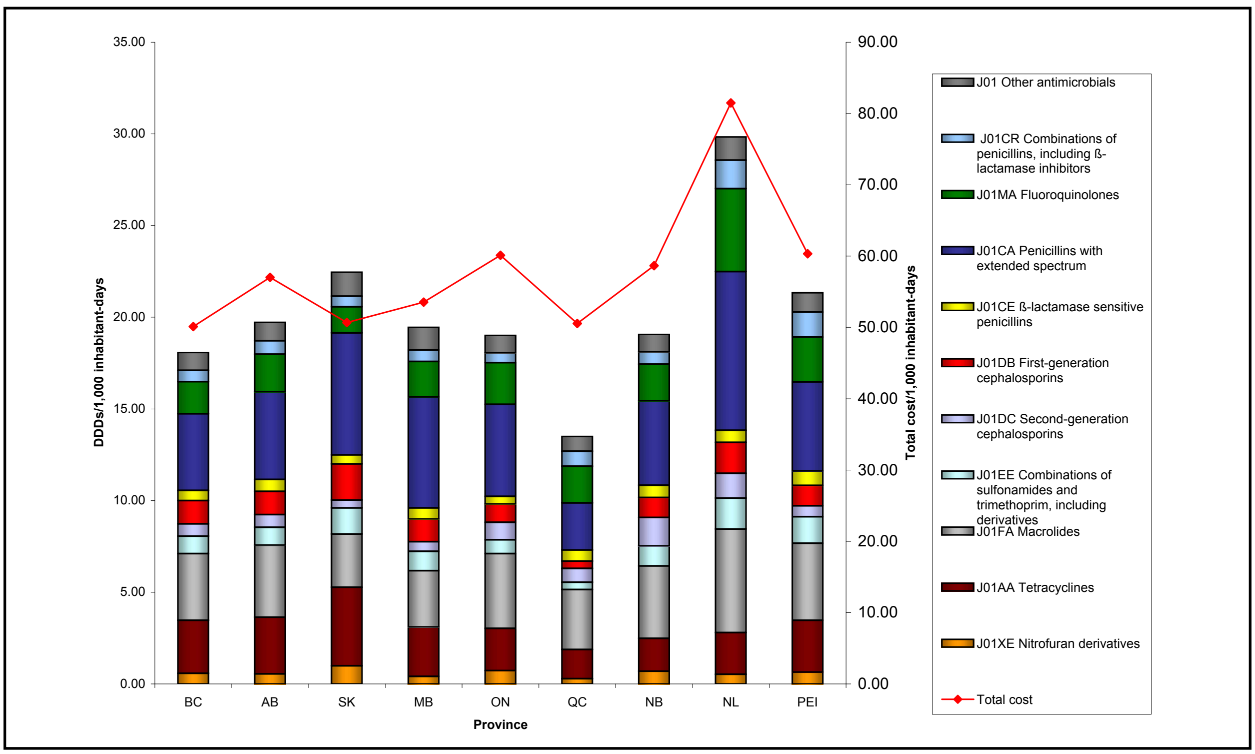
Table 27. Total consumption (DDDs/1,000 inhabitant-days) of oral antimicrobials dispensed by retail pharmacies in Canadian provinces, 2007.

	ATC Class		DDDs/1,000 inhabitant-days									
			BC	AB	SK	MB	ON	QC	PEI	NB	NS	NL
	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	0.62	0.73	0.59	0.63	0.53	0.82	1.36	0.68	0.88	1.54
	J01DD	Third-generation cephalosporins	0.07	0.05	0.02	0.04	0.08	0.04	0.26	0.07	0.10	0.15
I	J01MA	Fluoroquinolones	1.74	2.05	1.42	1.93	2.28	2.00	2.44	1.99	1.85	4.53
	J01XA	Glycopeptides	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
	J01XD	Imidazole	0.24	0.25	0.27	0.29	0.24	0.19	0.22	0.22	0.27	0.30
	J01XX	Linezolid	0.00	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA	< 0.01	< 0.01	< 0.01
	J01CA	Penicillins with extended spectrum	4.18	4.78	6.66	6.05	5.02	2.56	4.86	4.60	4.90	8.66
	J01CE	ß-lactamase sensitive penicillins	0.56	0.65	0.49	0.60	0.42	0.61	0.78	0.67	0.69	0.66
	J01CF	ß-lactamase resistant penicillins	0.21	0.19	0.43	0.57	0.20	0.17	0.24	0.18	0.24	0.43
	J01DB	First-generation cephalosporins	1.26	1.26	1.97	1.24	0.99	0.40	1.11	1.09	1.20	1.68
	J01DC	Second-generation cephalosporins	0.67	0.69	0.42	0.52	0.96	0.75	0.60	1.55	1.19	1.36
II	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	0.96	0.98	1.43	1.06	0.75	0.39	1.45	1.09	1.16	1.69
	J01FA	Macrolides	3.64	3.93	2.90	3.07	4.08	3.27	4.20	3.94	3.86	5.66
	J01FF	Lincosamides	0.39	0.47	0.46	0.32	0.36	0.34	0.30	0.38	0.37	0.24
	J01GB	Aminoglycosides	NA	NA	NA	NA	< 0.01	NA	NA	NA	NA	NA
	J01MB	Other quinolones, excluding fluoroquinolones	NA	NA	NA	< 0.01	NA	< 0.01	NA	NA	NA	NA
	J01RA	Sulfonamide combinations, excluding trimethoprim	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01	0.02
	J01XC	Steroid antimicrobials	< 0.01	< 0.01	NA	NA	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	NA
	J01AA	Tetracyclines	2.89	3.09	4.29	2.69	2.31	1.60	2.83	1.80	2.85	2.27
	J01EA	Trimethoprim, including derivatives	0.04	0.04	0.11	0.02	0.06	0.06	0.01	0.06	0.02	0.11
III	J01EB	Short-acting sulfonamides	NA	NA	NA	NA	< 0.01	< 0.01	NA	NA	NA	NA
	J01EC	Intermediate-acting sulfonamides	< 0.01	< 0.01	NA	NA	< 0.01	< 0.01	NA	NA	NA	NA
	J01XE	Nitrofuran derivatives	0.57	0.55	0.98	0.41	0.72	0.28	0.64	0.69	0.92	0.52
	J01XX	Fosfomycin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
NC	J01XX	Methenamine	0.02	0.01	0.01	< 0.01	0.01	0.01	< 0.01	0.01	< 0.01	0.01
	J01	**Total**	**18.06**	**19.72**	**22.46**	**19.44**	**19.00**	**13.48**	**21.33**	**19.06**	**20.49**	**29.83**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

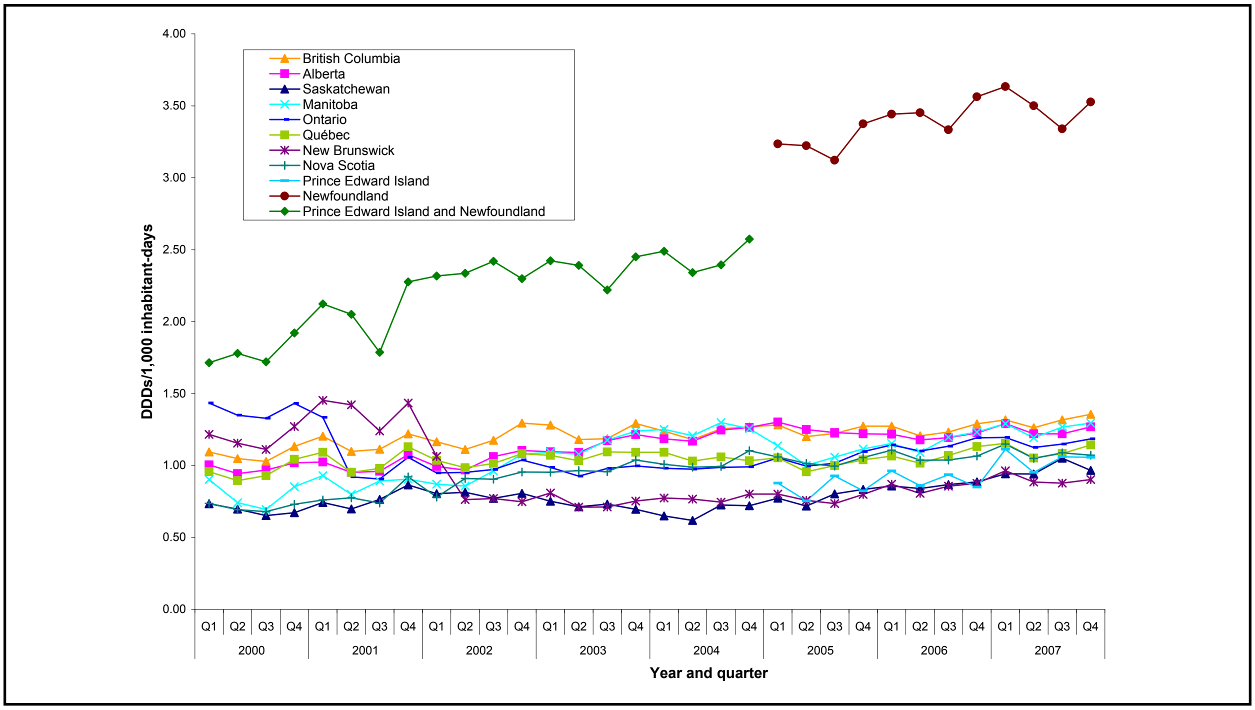
ATC = Anatomical Therapeutic Chemical. DDD = Defined daily dose. NA = Not available. NC = Not classified.

Figure 37. Total consumption (DDDs/1,000 inhabitant-days) of oral antimicrobials dispensed by retail pharmacies in Canadian provinces, 2007.



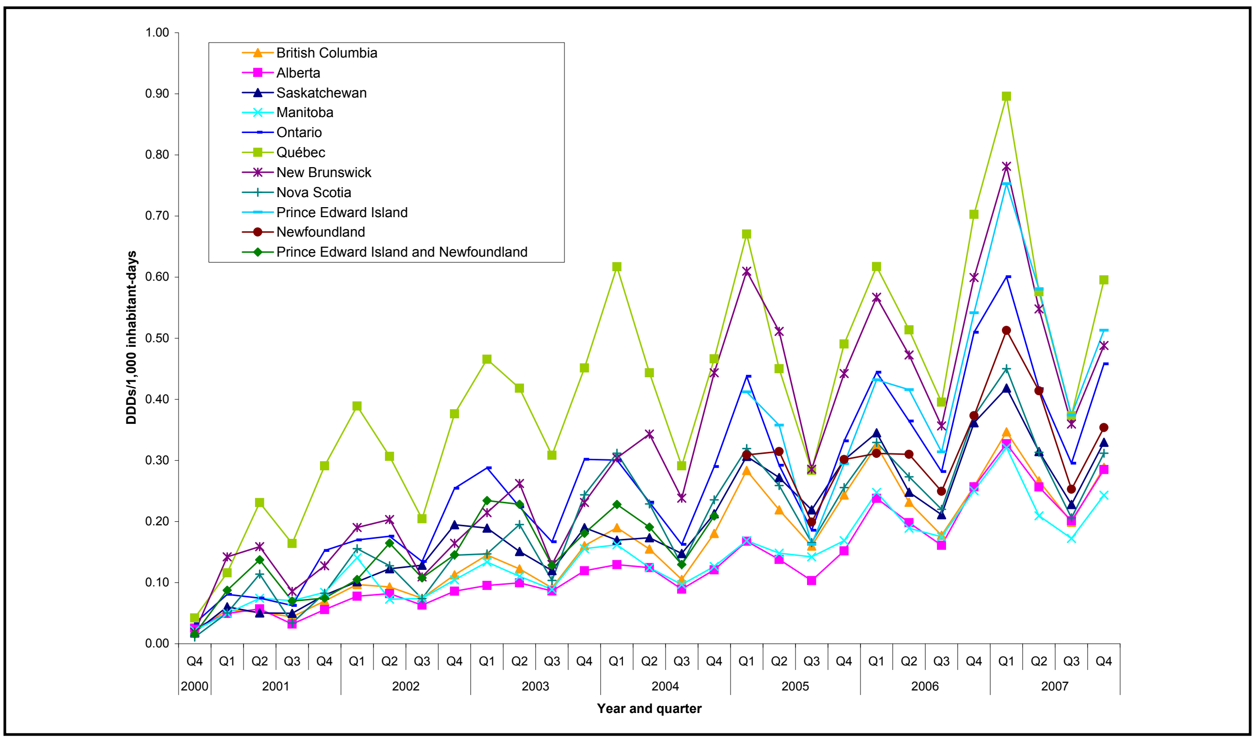
Alphanumeric codes in the legend represent Anatomical Therapeutic Chemical classes of antimicrobials.
DDD = Defined daily dose.

Figure 38. Total consumption (DDDs/1,000 inhabitant-days) of oral ciprofloxacin dispensed by retail pharmacies in Canadian provinces, 2000–2007.



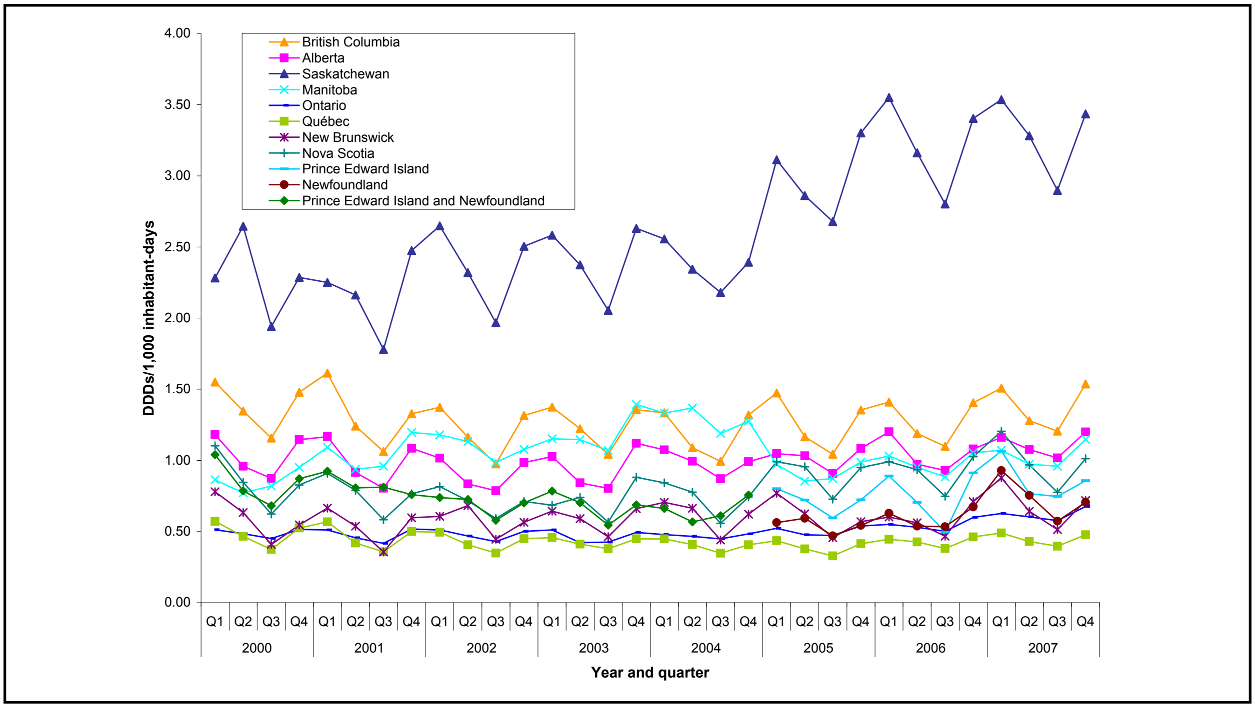
DDD = Defined daily dose.

Figure 39. Total consumption (DDDs/1,000 inhabitant-days) of oral moxifloxacin dispensed by retail pharmacies in Canadian provinces, 2000–2007.



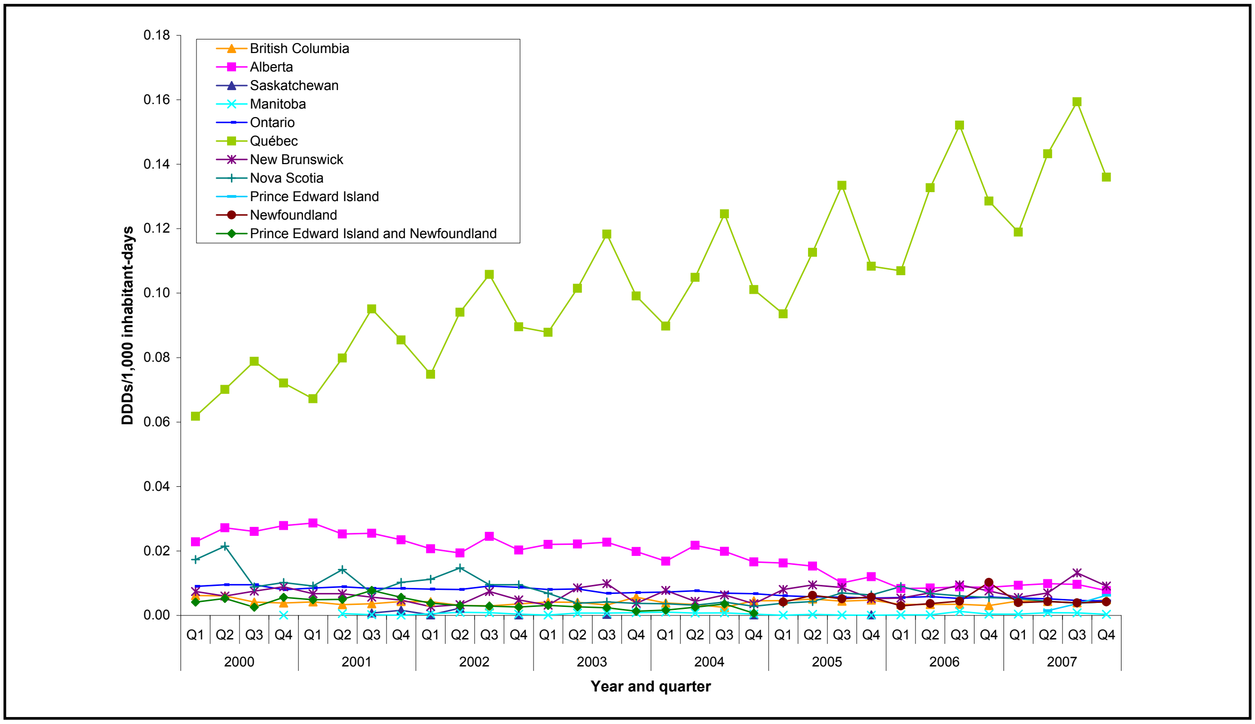
DDD = Defined daily dose.

Figure 40. Total consumption (DDDs/1,000 inhabitant-days) of oral doxycycline dispensed by retail pharmacies in Canadian provinces, 2000–2007.



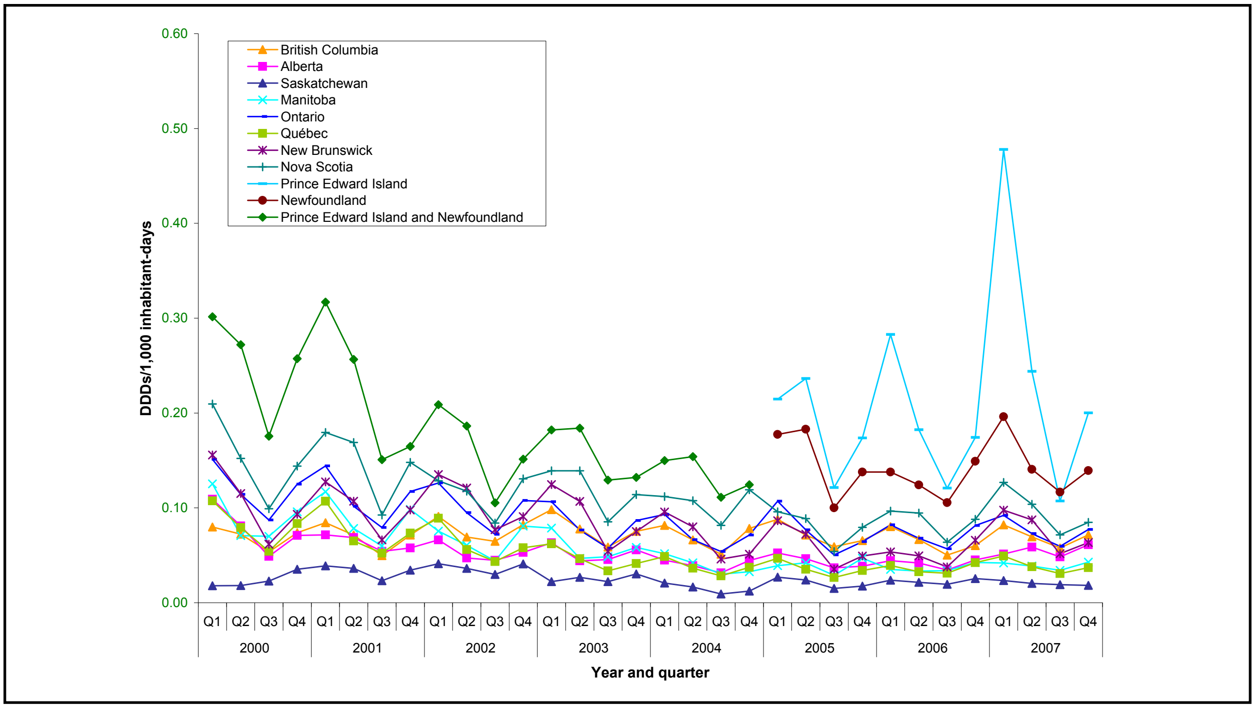
DDD = Defined daily dose.

Figure 41. Total consumption (DDDs/1,000 inhabitant-days) of oral cefadroxil dispensed by retail pharmacies in Canadian provinces, 2000–2007.



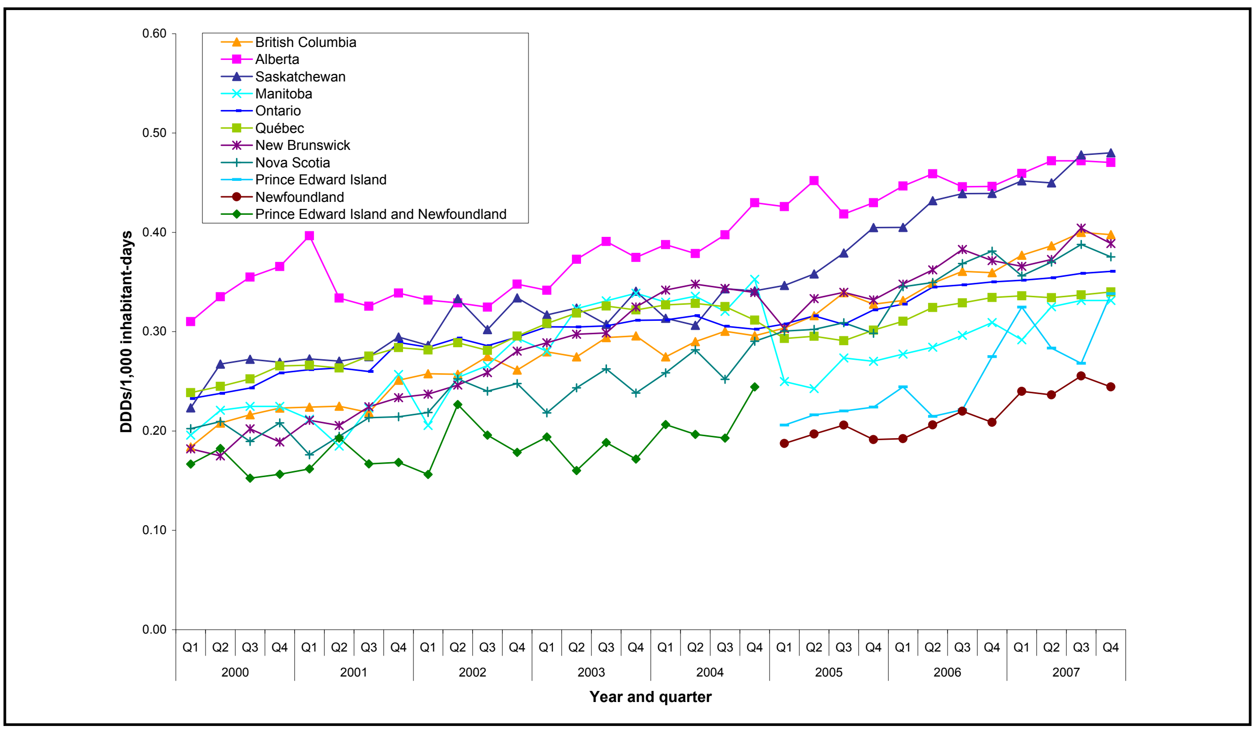
DDD = Defined daily dose.

Figure 42. Total consumption (DDDs/1,000 inhabitant-days) of oral cefixime dispensed by retail pharmacies in Canadian provinces, 2000–2007.



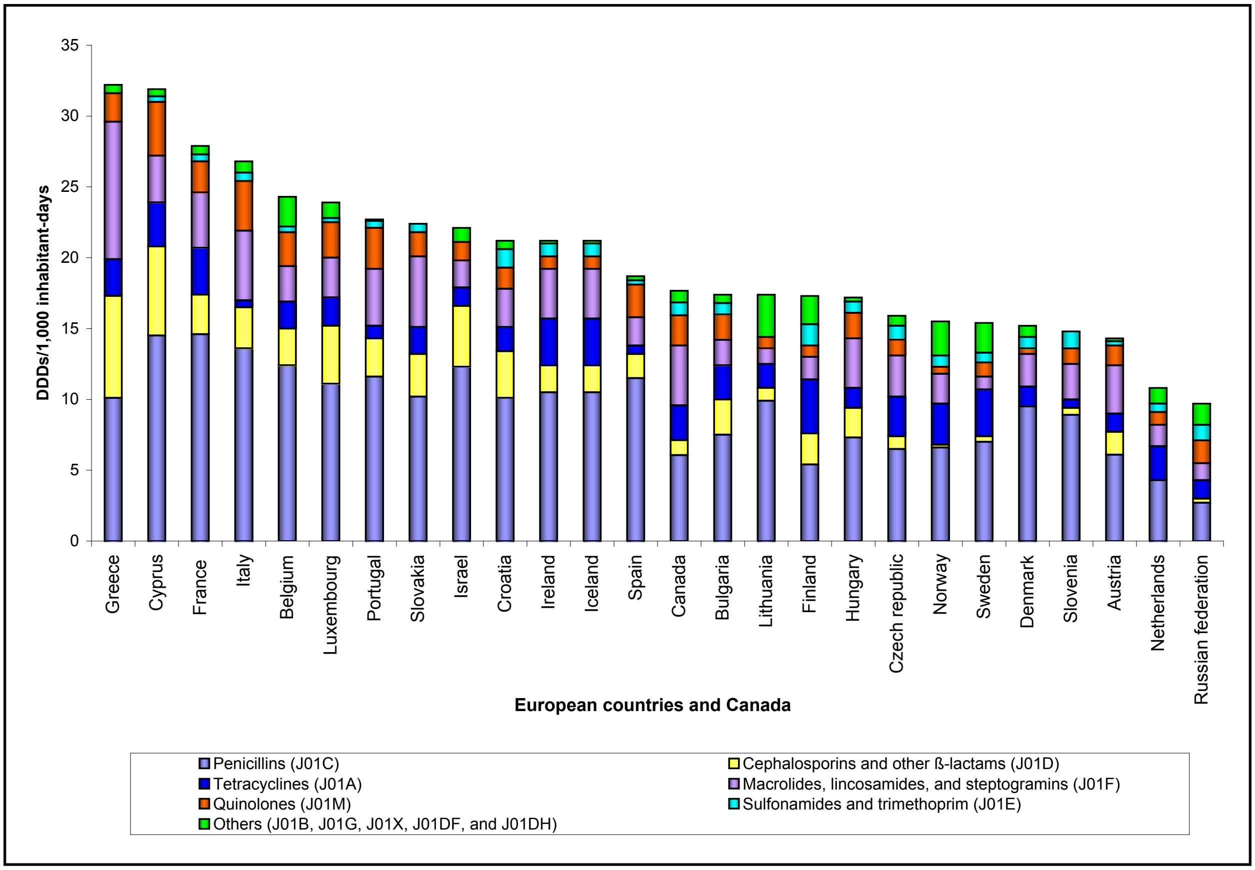
DDD = Defined daily dose.

Figure 43. Total consumption (DDDs/1,000 inhabitant-days) of oral clindamycin dispensed by retail pharmacies in Canadian provinces, 2000–2007.



DDD = Defined daily dose.

Figure 44. Antimicrobial consumption (DDDs/1,000 inhabitant-days) in 27 European countries and Canada[21]; European Surveillance of Antimicrobial Consumption and CIPARS 2006.



Alphanumeric codes in parentheses represent Anatomical Therapeutic Chemical classes of antimicrobials.

DDD = Define daily dose.

[21] ESAC, 2009. ESAC – European Surveillance of Antimicrobial Consumption ESAC Yearbook 2006. Available at: http://www.esac.ua.ac.be/main.aspx?c=*ESAC2&n=50036. Accessed June 2009.

Animals

For Antimicrobials used in food-animal production and veterinary medicine are accessed through a complex network of sales and distribution channels. Since 1999, Health Canada and the Public Health Agency of Canada (PHAC) have been investigating several sources and means of acquiring reliable and valid data on antimicrobial use in food animals. At the federal level, there is no current legislative mechanism by which to acquire these data. Over-the-counter (OTC) antimicrobial sales (including antimicrobials for use in feed) and the practice of veterinary medicine are regulated by each province/territory.

PHAC has worked with academic institutions to acquire data on antimicrobial use in animals through farm—and veterinary practice-based projects involving the dairy, pork, sheep, beef, and companion animal sectors. Research is also being conducted to develop antimicrobial-use estimation models in the absence of ongoing comprehensive data collection.

Funding to establish the *Farm Surveillance* component of CIPARS was provided in 2003. Antimicrobial-use data collected in 2007 from swine production are summarized in this report.

Please check the CIPARS website[22] for updates on antimicrobial use in animals, including the latest data from the Canadian Animal Health Institute (CAHI), research publications, and CIPARS *Farm Surveillance*.

Canadian Animal Health Institute

The CAHI[23] is the trade association representing the companies that manufacture and distribute drugs for administration to companion, sporting, and food animals in Canada. The association estimates that its members' sales represent over 95% of all sales of licensed animal pharmaceutical products in Canada. The CAHI coordinated electronic collection of data from its members and 1 non-member on the total kilograms of antimicrobials distributed by Canadian companies in 2006 and 2007. Data on the total number of individual products distributed were provided and aggregated by active ingredient for analysis. Data collection and analysis were performed by a third party, Impact Vet.[24]

Acquired data were aggregated by antimicrobial class and provided to PHAC by CAHI (Table 28). Data regarding all licensed antimicrobials for use in food, sporting, and companion animals and fish were included. These data do not represent actual antimicrobial use in a given year; rather, they reflect the volume of antimicrobials distributed by manufacturers. Distribution values should approximate amounts used, particularly when data from more than 1 year are included. However, when data from only 1 year are included, distribution values may vary from amounts actually used because of the time lag between distribution and actual use, as well as stockpiling of antimicrobials at various points in the distribution system. The data do not include antimicrobial products imported for personal use (own use import, OUI) under the personal-use provision of the federal *Food and Drugs Act & Regulations*, nor do they include active pharmaceutical ingredients (API) drugs imported in non-dosage form and compounded by a licensed pharmacist or veterinarian and used in veterinary medicine and food-animal production. See the 2006 CIPARS report for more information[25].

The CAHI data on the distribution of antimicrobials for use in animals provide a context through which to interpret other data on antimicrobial use in animals generated through research and farm data collection. The CAHI data also provide a means to monitor gross temporal changes in antimicrobial use in animals.

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22 See: http://www.phac-aspc.gc.ca/cipars-picra/index-eng.php. Accessed August 2009.

23 See: http://www.cahi-icsa.ca. Accessed August 2009.

24 Division of AgLine/TI Communications Ltd. See: http://www.impactvet.com. Accessed August 2009.

25 See: http://www.phac-aspc.gc.ca/cipars-picra/2006-eng.php. Accessed August 2009.

Table 28. Kilograms of antimicrobials in dosage form distributed in Canada for use in animals; Canadian Animal Health Institute, 2006 and 2007.

Antimicrobial class	2006	2007	Percentage change from 2006 to 2007
	Kg of active ingredients		
Aminoglycosides	5,121.60	4,302.20	
ß-Lactams, excluding cephalosporins	58,538.00	52,594.00	
Cephalosporins	702.00	850.00	
Fluoroquinolones	591.00	443.10	
Ionophores, chemical coccidiostats, and arsenicals	455,753.00	445,952.00	
Lincosamides	67,825.30	55,872.30	
Macrolides and pleuromutilins	136,496.50	118,724.80	
Tetracyclines	847,280.60	753,168.40	
Trimethoprim and sulfonamides	50,789.00	38,961.00	
Other antimicrobials	143,029.00	146,879.80	
Total	**1,766,126.00**	**1,617,747.60**	**-8.40%**

Values do not include own use imports or active pharmaceutical ingredients (API) used in compounding.

In 2007, the overall total kg of antimicrobials distributed for sale by CAHI member companies decreased by 8.4% as a percentage of the 2006 total. Decreases were reported for all classes of antimicrobials except cephalosporins and other antimicrobials.

Farm Surveillance in Pigs

In Canada, pigs are typically maintained in the grower-finisher production phase for 16 to 20 weeks, and therefore the replacement rate of pigs in a grower-finisher barn is approximately 3 times per year. The surveillance program was designed for administration of the antimicrobial-use questionnaire to each herd 3 times annually, at approximately 4 month intervals, so antimicrobial use during the calendar year could be described. Three completed antimicrobial-use questionnaires were submitted for 47 sentinel herds, 2 questionnaires were submitted for 32 herds, and 1 questionnaire was submitted for 23 herds. Antimicrobial use may be underestimated in herds for which 3 completed questionnaires were not submitted in 2007.

Data on antimicrobial use were not provided for every herd for every route of antimicrobial administration. Data were most complete for antimicrobial use in feed (98% [100/102] of herds represented) and least complete for antimicrobial use in water (87% [89/102] of herds represented). It is probable that herds for which antimicrobial use in water or injections was not reported had no exposure to antimicrobials because the questionnaire included a checkbox for “no exposure,” and specific data were requested when exposure did occur. It is likely that when antimicrobial use in water or injections was not reported, respondents simply failed to mark the checkbox for “no exposure”; however, for completeness, these variables were treated as missing data. The same situation was not true for antimicrobial use in feed because descriptions of diets were requested regardless of their antimicrobial content. If the herd representatives failed to provide data on antimicrobial use in feed, generally no ration information was provided. If this information was missing it was assumed that these data were not available, either in the detail required or at all, and were classified as missing information.

Data from the antimicrobial-use questionnaires were compiled so that any reported exposure mentioned in a single questionnaire was classified as an exposure in that herd in 2007. The questionnaires were designed to collect quantitative antimicrobial-use data for antimicrobial exposures through feed and water, but not through injection. However, the results reported here are solely qualitative and do not include exposure rate, duration, or dose of antimicrobial. This is because of inconsistencies in the reported size of the population at risk and exposure time in some herds. The questionnaires have since been redesigned for future use to more precisely measure the number of pigs in the population of interest, the number of days pigs are in the grower-finisher production phase, the tonnes of feed fed, and the duration of antimicrobial exposure through feed.

As a result of changes to the data collection methods between 2006 and 2007, data for erysipelas, atrophic rhinitis, and infections with *Streptococcus suis* and *Haemophilus parasuis* were missing for some herds in 2007. These missing data were particularly evident for swine breeding herds that supplied the grower-finisher herds, from which information on health status was collected on an annual basis only. For some herds, health status was determined solely through the presence or absence of clinical signs of particular diseases. This may have resulted in some misclassification of the disease status of those herds.

Herd characteristics

Twenty-nine veterinarians representing 108 sentinel swine herds were enrolled in CIPARS *Farm Surveillance* in 2007. Of these, 23 veterinarians submitted questionnaires from 102 herds. The herds were distributed in the following provinces: Alberta, 23.5% (24/102); Saskatchewan, 4.9% (5/102); Manitoba, 7.8% (8/102); Ontario, 24.5% (25/102); and Québec, 25.5% (26/102). Additionally there were 13.7% (14/102) corporate herds in western Canada where the province was not disclosed to CIPARS staff to maintain producer anonymity. Veterinarians of 52% (53/102) of herds reported continuous flow management in the grower-finisher production phase, and veterinarians of 48% (49/102) of herds reported all-in-all-out management. Half of the sentinel herds had a grower-finisher barn capacity that exceeded 1,992 pigs (median barn capacity, 1,992 pigs; interquartile range [IQR] 1,050 to 3,200 pigs). Veterinarians of 2 sentinel herds provided only herd characteristics and management data, whereas veterinarians of 100 herds provided herd characteristics, management, and antimicrobial-use data.

Description of antimicrobial use

Of the 102 swine herds for which data were provided by questionnaire, 2 were missing data on antimicrobial use. Therefore, the results reported here pertain to 100 sentinel herds. Data on antimicrobial use in water were provided for 89% (89/100) of herds, data on antimicrobial use in injections were provided for 94% (94/100) of herds, and data on antimicrobial use in feed were provided for all herds. Data on antimicrobial use via all 3 routes of administration were provided for 88% (88) of herds. For 1 herd, data were provided for antimicrobial use in feed and water but not injections. For 6 herds, data were provided for antimicrobial use in feed and injections but not water. For 5 herds, data were provided for antimicrobial use in feed but not water or injections.

In the grower-finisher production phase, antimicrobial use in 91% (91/100) of herds reportedly occurred via at least 1 route. Representatives of 5 of the remaining 9 herds reported no antimicrobial use. Representatives of the other 4 herds reported no antimicrobial use via the routes for which they provided data, but the status of these herds could not be determined because responses were not provided for every administration route (i.e. it could not be determined whether antimicrobials were used via routes for which responses were missing). In sentinel herds, antimicrobial use was more common in feed 75% (75/100) and injections 77%, (72/94) than in water 40% (36/89). Representatives from half of the sentinel herds reported use of antimicrobials from 3 classes (median, 3 antimicrobial classes; IQR, 2 to 4; Figure 45). The median number of active ingredients reportedly used per herd was 3.5 (IQR, 2 to 5).

The most commonly used antimicrobials in the sentinel swine herds belonged to the classes macrolides and lincosamides 74% (74/100), followed by penicillins 71% (71/100; Figure 46). Results for specific antimicrobials according to the classes to which they belong are provided in Table 29). Antimicrobials of the macrolides class were the most common antimicrobials administered through feed and were most commonly used to prevent disease or promote growth (Figure 46 and Figure 49). Exposure to macrolides often persisted until pigs were close to market (Figure 47). Antimicrobials of the penicillins class were the most common antimicrobials administered through water. Penicillins were most commonly administered through water to pigs that weighed less than 60 kg and were predominantly used to treat respiratory disease (Figure 48 and Figure 50). Penicillins were also the most common drugs administered through injection, followed by extended-spectrum cephalosporins (Figure 46). With the exception of injectable ceftiofur use 31% (29/94), use of Veterinary Drugs Directorate Category I antimicrobials was uncommon in sentinel herds (virginiamycin use, 2% [2/100]; Table 29).

Health status

The number of herds for which health status was reported varied by disease as well as by pig type. Representatives of 75 herds provided some information on the health status of the breeding herds, and those of 99 herds provided some information on the health status of the grower-finisher pigs. Overall, information was more commonly provided for grower-finisher pigs than for breeding herds. For an average of 85 grower-finisher herds (median, 83 herds), herd status per disease was reported, and for an average of 64 breeding herds (median, 66 herds), the same was true. Information was also more commonly provided for diseases of particular importance to pig health, including porcine reproductive and respiratory syndrome (PRRS; 72 breeding herds and 94 grower-finisher herds) and porcine circovirus–associated disease (PCVAD; 68 breeding herds and 97 grower-finisher herds). In comparison, status regarding clinical infection with *Salmonella* was reported for 47 breeding herds and 70 grower-finisher herds.

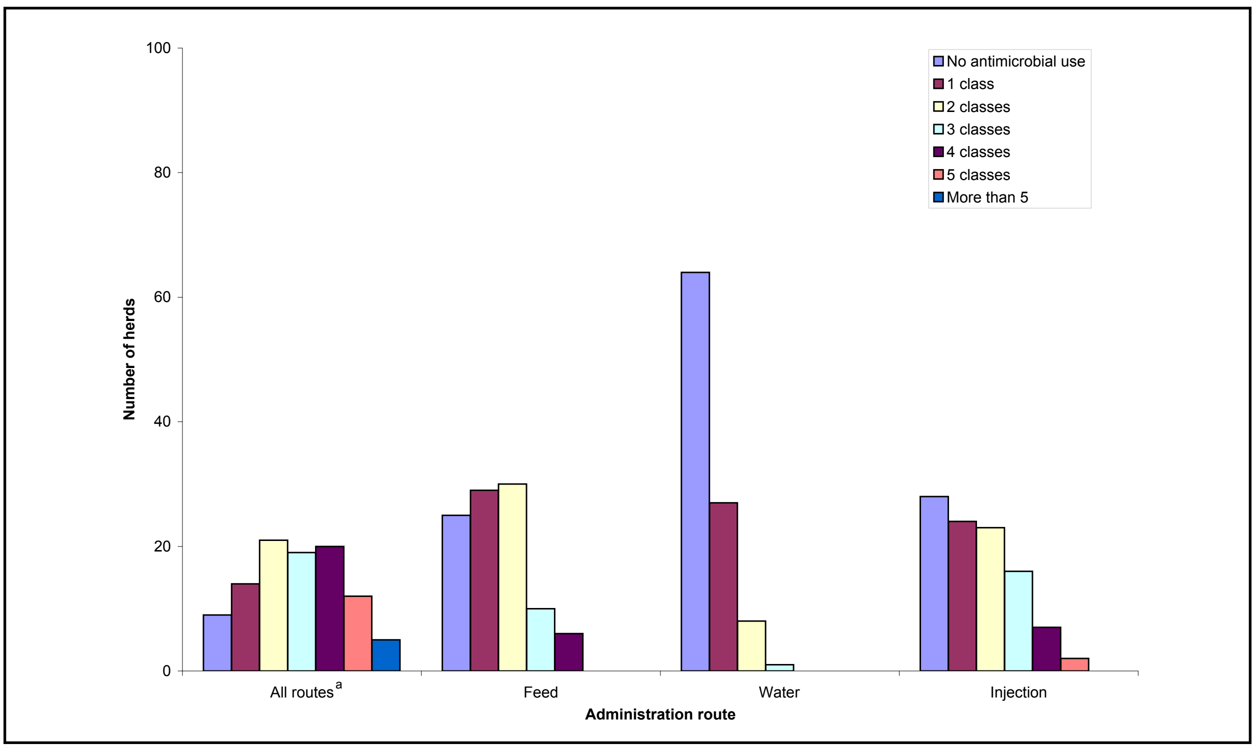
In breeding herds, a positive disease status was most commonly reported for clinical disease associated with *Escherichia coli* 92% (61/66) of herds and *Streptococcus suis* 92% (58/63) of herds and for PCVAD 84% (57/68) of herds; (Figure 51). One breeding herd was reportedly negative for all diseases included in the questionnaire. Data were collected on the presence of clinical *Leptospira* and parvovirus in breeding herds, but because most herds (100% and 98% respectively) vaccinated all sows against these pathogens and vaccination is highly effective, these diseases were not reported.

In grower-finisher herds, a positive status was most commonly reported for PCVAD 91% (88/97) and infections with *S. suis* 82% (66/80) and *H. parasuis* 71% (55/77; Figure 52).

Information reported under the "other disease" category included lameness in breeding herds 83% (50/60) and bacterial pneumonia, gastric torsion, and coccidiosis in grower-finisher pigs (1 sentinel herd each). Information was also provided for some grower-finisher herds on lameness 71% (55/77) and neurological problems (2/16) in pigs.

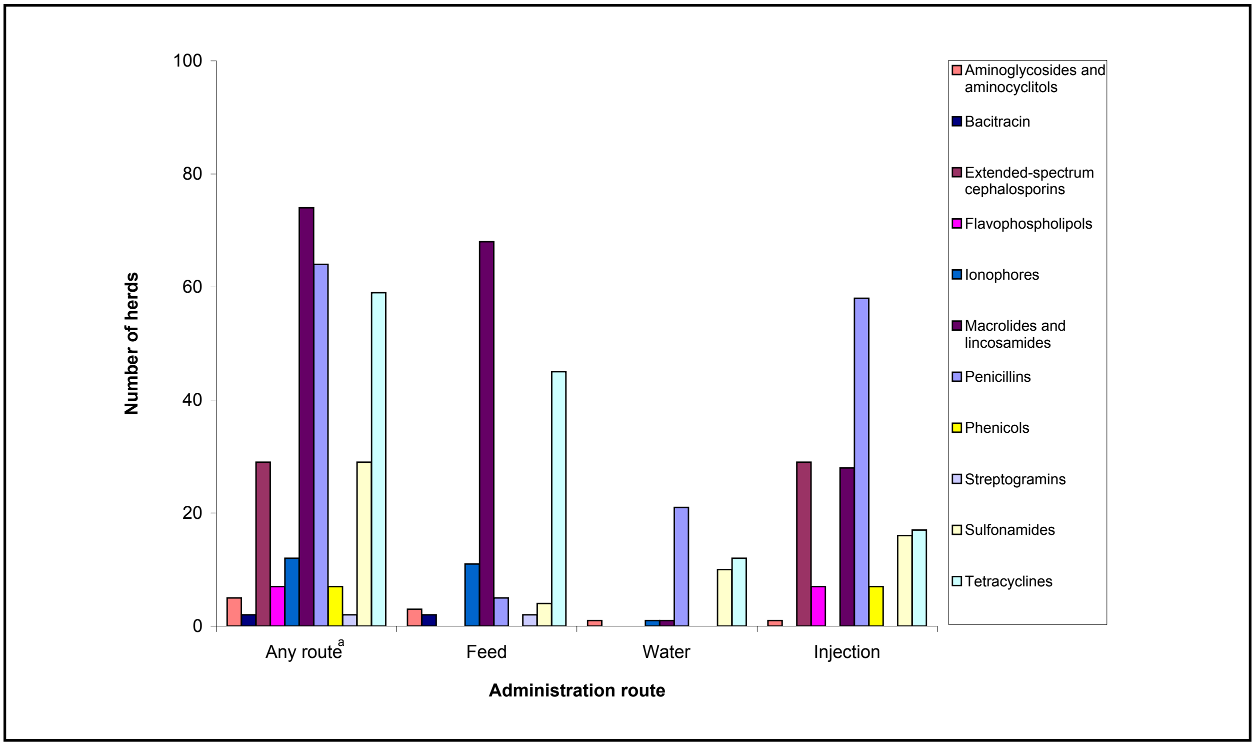
In 2007, the Category I antimicrobials ceftiofur and virginiamycin were used on 31% and 2% of grower-finisher herds respectively. Ceftiofur was only used as an injectable and virginiamycin was only used in feed. The most commonly used antimicrobials overall were macrolides and lincosamides followed by penicillins. Macrolides and lincosamides were primarily administered throughout the grower-finisher period via the feed. Penicillins were administered primarily via the water or injection. There were at least 5 herds that did not utilize antimicrobials by any route in the grower-finisher production stage.

Figure 45. Number of sentinel swine herds (n = 100) with reported use of no antimicrobials, a single antimicrobial class, or multiple antimicrobial classes, by administration route; *Farm Surveillance,* 2007.



[a] All routes = The sum of antimicrobial classes reportedly used in each herd, counting each class no more than once, regardless of number of administration routes reported.

Figure 46. Number of sentinel swine herds (n = 100) with reported use of specific antimicrobial classes, by administration route; *Farm Surveillance*, 2007.



[a] "Any route" included use of an antimicrobial class by feed, water, injection, or any combination of these routes.

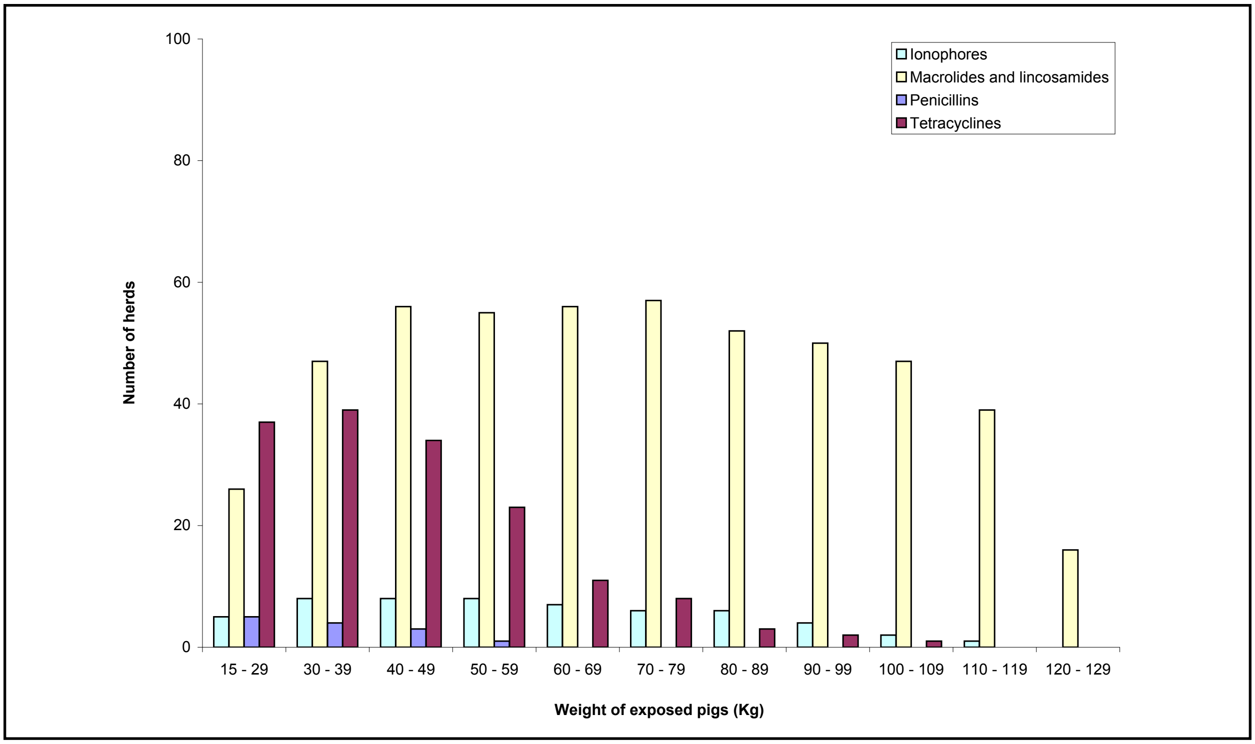
Table 29. Number of sentinel swine herds (n = 100) with reported use of antimicrobial by administration route; *Farm Surveillance*, 2007.

	Antimicrobial Class	Antimicrobial	Administration route			
			Any route	Feed	Water	Injection
I	Extended spectrum cephalosporins	Ceftiofur	29			29
	Streptogramins	Virginiamycin	2	2		
	Aminoglycosides	Neomycin	2	1	1	
	Macrolides and lincosamides	Erythromycin	1			1
		Lincomycin	42	34	1	13
		Tiamulin	9	7		2
		Tulathromycin	12			12
II		Tylosin	52	46		10
	Penicillins	Amoxicillin	3		3	
		Ampicillin	9			9
		Penicillins G	63	5	14	58
		Phenoxymethyl penicillin	6		6	
	Sulfonamides	Trimethoprim-sulfadoxine	22		5	16
	Aminoglycosides	Spectinomycin	3	2		1
	Bacitracins	Bacitracin	2	2		
	Phenicols	Florfenicol	7			7
III	Sulphonamides	Sulfonamides (unspecified)	9	4	5	
	Tetracyclines	Chlortetracycline	45	43	4	
		Oxytetracycline	18	2		17
		Tetracyclines hydrochloride	8		9	
IV	Flavophospholipols	Bambermycin	3	3		
	Ionophores	Salinomycin	12	11	1	

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

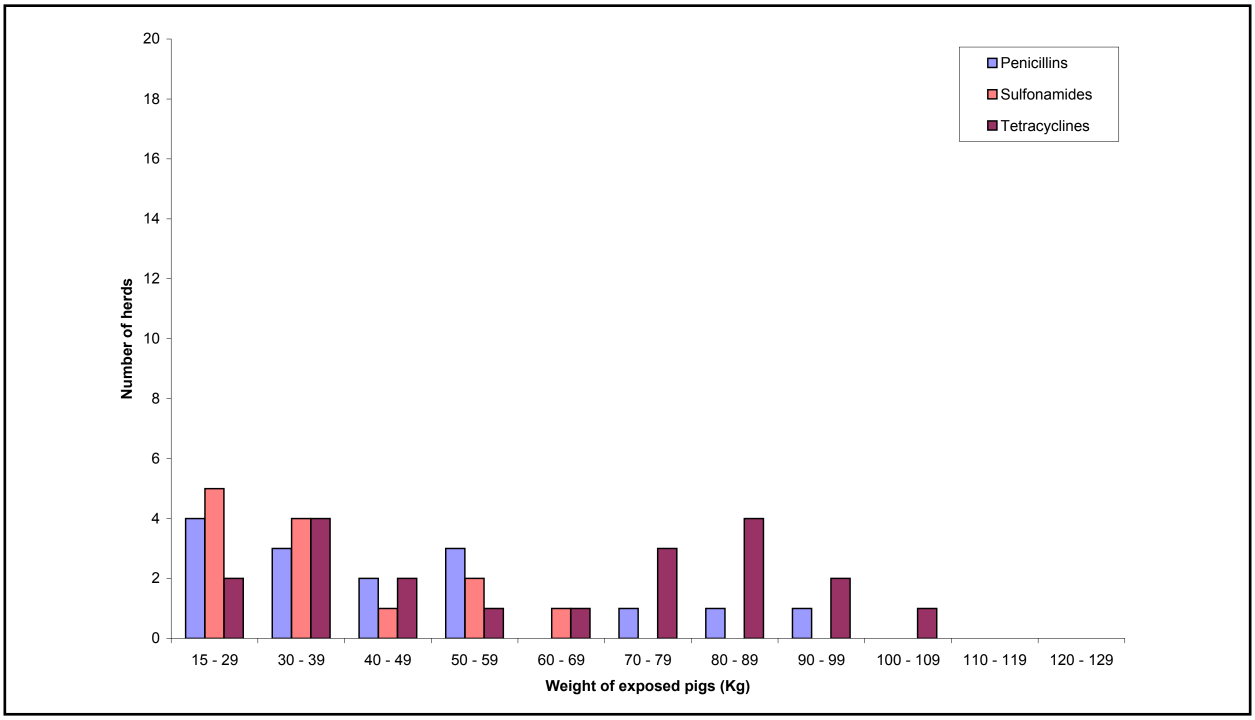
Any route = Use of an antimicrobial class by feed, water, injection, or any combination of these routes.

Figure 47. Number of sentinel swine herds (n = 100) with reported use of specific antimicrobial classes in feed, by weight category of pigs; *Farm Surveillance*, 2007.



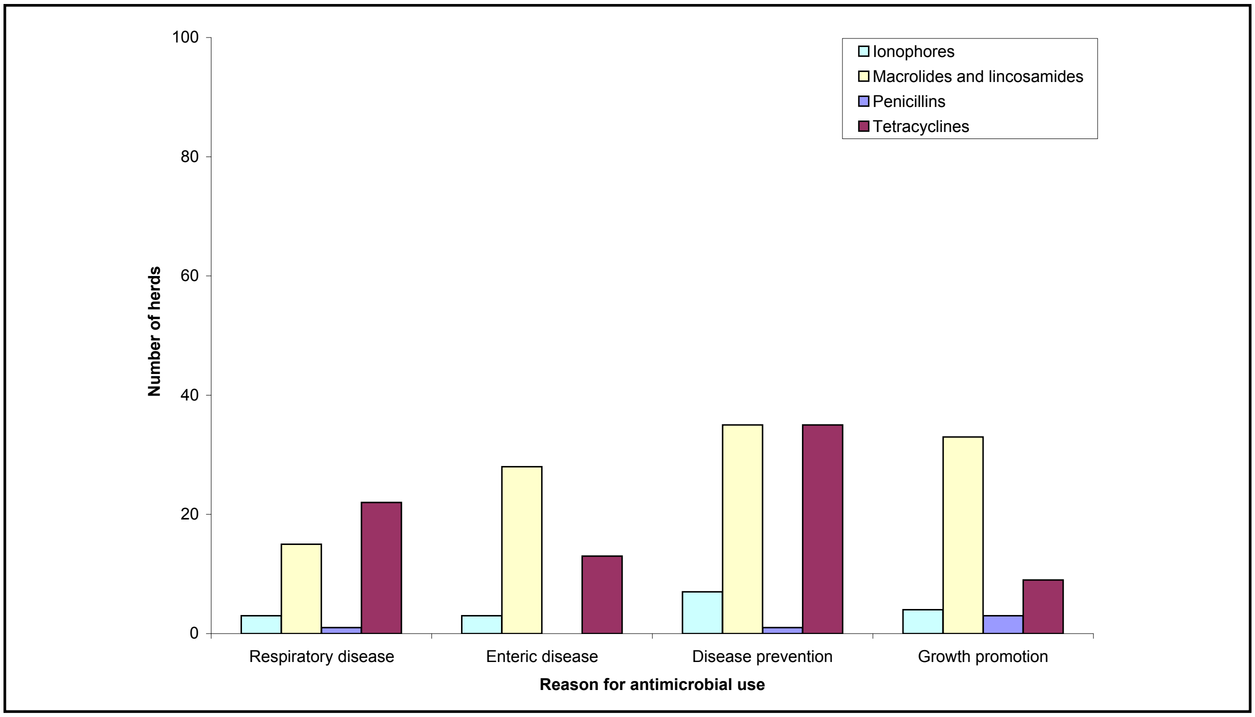
Data regarding antimicrobial classes in less than 5 herds are not presented.

Figure 48. Number of sentinel swine herds (n = 100) with reported use of specific antimicrobial classes in water, by weight category of pigs; *Farm Surveillance*, 2007.



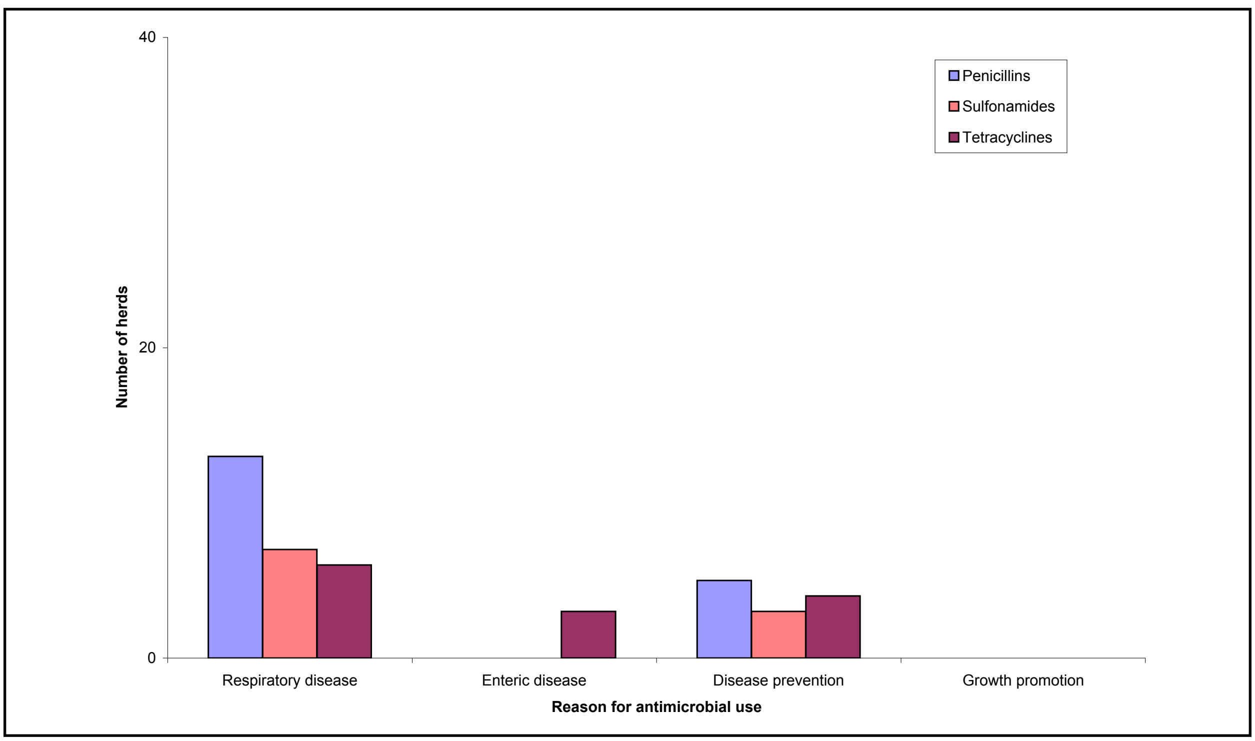
Data regarding antimicrobial classes used in water in less than 5 herds are not presented.

Figure 49. Number of sentinel swine herds (n = 100) with reported use of specific antimicrobial classes in feed, by reason for use; *Farm Surveillance*, 2007.



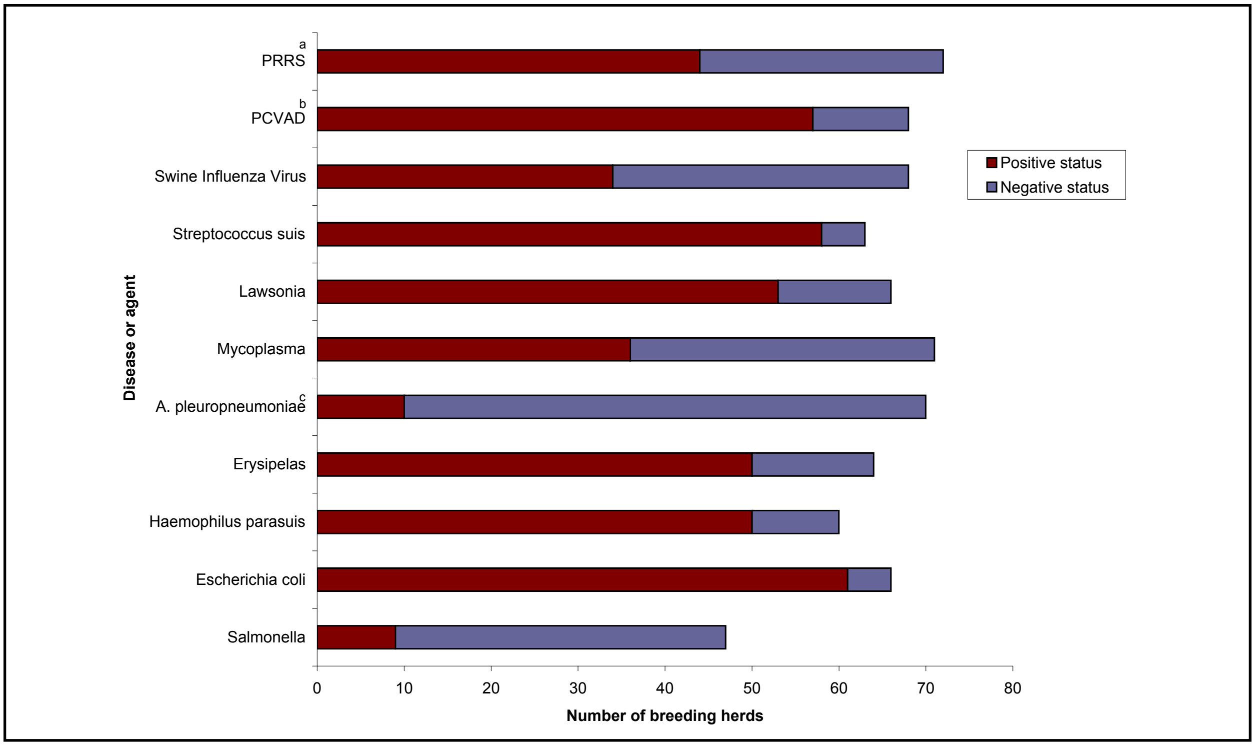
Data regarding antimicrobial classes used in feed in less than 5 herds are not presented.

Figure 50. Number of sentinel swine herds (n = 100) with reported use of specific antimicrobial classes in water, by reason for use; *Farm Surveillance*, 2007.



Data regarding antimicrobial classes used in water in less than 5 herds are not presented.

Figure 51. Numbers of breeding swine herds for which disease status (positive or negative) was reported, by disease; *Farm Surveillance, 2007*.

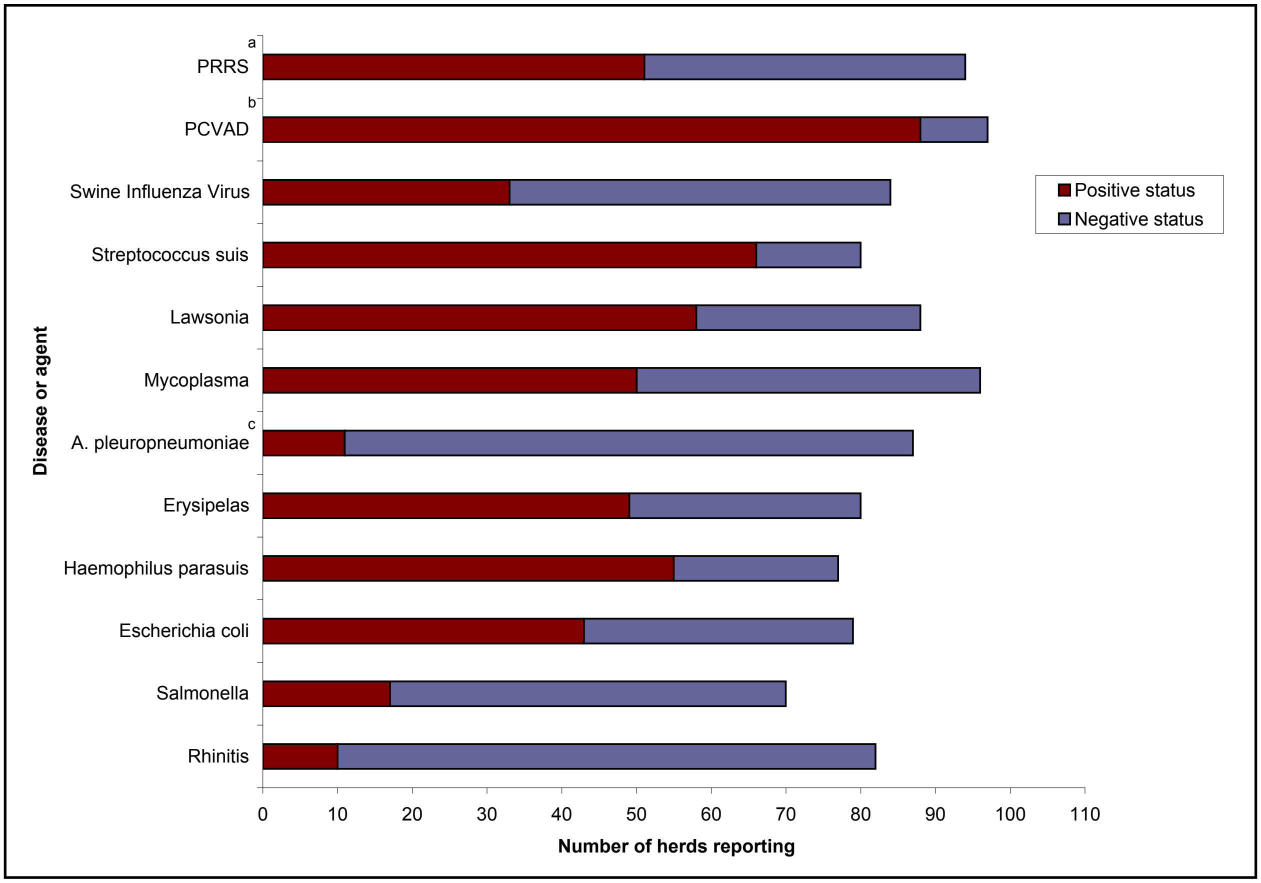


[a] PRRS = Porcine reproductive and respiratory syndrome.

[b] PCVAD = Porcine circovirus–associated disease.

[c] *Actinobacillus pleuropneumoniae*.

Figure 52. Number of grower-finisher swine herds for which disease status (positive or negative) was reported, by disease; *Farm Surveillance*, 2007.



[a] PRRS = Porcine reproductive and respiratory syndrome.
[b] PCVAD = Porcine circovirus–associated disease.
[c] *Actinobacillus pleuropneumoniae.*

Section Three - Public Health Agency of Canada Research Collaborations

Box 1. Prevalence and antimicrobial susceptibility of *Salmonella* and generic *Escherichia coli* isolated from liquid whole egg in Ontario.

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Most cases of human salmonellosis are caused by ingestion of *Salmonella*-contaminated food. Despite the implementation of control programs in agricultural and food-production industries, salmonellosis remains the second most commonly reported foodborne bacterial disease in Canada. *Salmonella* Enteritidis is consistently among the most common serovars recovered from affected people in Canada. Contaminated eggs and egg products are typical sources of this serovar.

Antimicrobial resistance contributes to the burden of infectious disease by limiting treatment options, increasing health-care costs, and increasing the duration and/or severity of illness. Unpasteurized liquid whole egg (LWE) represents a surrogate sampling point for monitoring *Salmonella* and AMR in eggs. The objective of this study was to estimate the prevalence and determine AMR patterns of *Salmonella* and generic *Escherichia coli* isolated from unpasteurized LWE obtained from 4 egg-breaking stations in Ontario. Three hundred LWE samples were collected from holding tanks between January 2007 and January 2008; the sampling frequency was proportional to production of LWE at each breaking station. Up to 5 *Salmonella* and 5 generic *E. coli* isolates were cultured from each LWE sample. *Salmonella* isolates were serotyped and phage typed by use of standard methods. A standard broth microdilution method was used to determine susceptibility of *Salmonella* and generic *E. coli* isolates to a test panel of 15 antimicrobials.

Salmonella was isolated from 21.0% (63/300) of LWE samples, yielding a total of 309 isolates. *Salmonella* Heidelberg was isolated from 11% (32/300) of samples and was the most common *Salmonella* serovar, accounting for 48.5% (150/309] of isolates). *Salmonella* Enteritidis was isolated from 1.7% (5/300) of samples and accounted for 8.1% (25/309) of isolates. Few *Salmonella* isolates were resistant to tetracycline (9.1%; 20/309), streptomycin (0.3%; 1/309), or both (2.6%; 8/309); most (90.6%; 280/309) were susceptible to all antimicrobials in the test panel.

Generic *E. coli* was recovered from 78.0% (234/300) of samples and 1,796 isolates were obtained. Of these, 1,139 (63.4%) were evaluated for antimicrobial susceptibility. Approximately half (51.9%; 591/1,139) of the generic *E. coli* isolates were resistant to 1 or more antimicrobials. Forty-four antimicrobial resistance patterns were detected; resistance to tetracycline only was the most common pattern.

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Box 2. Application of analytic models to ciprofloxacin minimum inhibitory concentrations of enteric *Campylobacter jejuni* isolates from human patients in Saskatchewan, 1999–2005.

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Increasing antimicrobial resistance (AMR) in *Campylobacter jejuni* from animals, food, and humans is a global public health concern. In particular, ciprofloxacin (CIP) resistance may limit clinical treatment options for campylobacteriosis, thereby increasing the burden of illness. The AMR data yielded through laboratory surveillance are typically categorized according to minimum inhibitory concentration (MIC) breakpoints. There is concern that such categorization may obscure subtle temporal shifts in MICs. Devising methods to detect shifts in MICs is important for early identification of selection pressure for bacterial resistance to antimicrobials that are critical to human health. Currently in Canada, representative data on AMR in *Campylobacter* in humans is scant; however, the Saskatchewan Disease Control Laboratory (SDCL) tests a large proportion of isolates from provincially-reported cases of *Campylobacter* infection. The objective of this study was to compare the abilities of statistical analytic models for categorized and MIC data to detect temporal changes in CIP resistance. We hypothesized that direct modeling of MIC data would be more sensitive than using dichotomized data to detect changes in CIP resistance over time. Ciprofloxacin MICs were determined by use of E-test strips for 1,014 *C. jejuni* isolates recovered from human fecal samples submitted to the SDCL from 1999 to 2005. A resistance breakpoint of ≥ 4.0 µg/mL was used for categorization. A logistic model was applied to the categorized data to determine the effect of year on the predicted probability of a non-susceptible isolate. A discrete-time survival model, with concentration-to-inhibition of growth as the “time-to-event,” was used to compare the predicted hazards for the range of MIC dilutions over the study period. Overall, the prevalence of CIP resistance was 8.8% (89/1,014). The logistic model revealed an overall decrease in the annual log-odds of resistance from 1999 to 2004, with a subsequent increase in 2005. The discrete-time survival model revealed an annual increase in the hazard probabilities for low MIC dilutions (0.064 to 0.25 µg/mL) through 2004, with a decrease in 2005. This trend for CIP resistance was similar to that of the logistic model. The significance of annual parameters in both models varied. The MIC survival model was not demonstrably more sensitive than the logistic model, attributable in part to the low number of isolates with moderate to high MICs. Additional comparison of the 2 models using data from a larger number of isolates is warranted.

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Box 3. Environmental household study.

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Sources of exposure to *Salmonella* and antimicrobial resistance profiles in generic *Escherichia coli* have been identified through outbreak investigations, retail surveys, abattoir sampling, and farm testing. However, little work has been carried out to investigate the role that the home environment might play in contributing to such exposures. In Canada, 2 separate surveys were carried out to identify baseline information on the presence of *Salmonella*, generic *E. coli*, and *Clostridium difficile* in the home environment.

The first survey, carried out between October 2005 and May 2006, consisted of 97 households. To identify and enrol households, advertising efforts were made through other relevant research projects conducted at the University of Guelph, advertisements in University of Guelph campus bi-weekly publications, and the Ontario Veterinary College listserv as well as past participant dissemination of brochures and emails. Households were visited to collect environmental samples, and owners were requested to submit fecal samples from all pets in the home. Households with fish tanks or ponds had water samples collected at the time of the visit. The second survey was carried out between January and May 2007 and consisted of 282 homes. Households were randomly selected and mailed a letter of invitation to participate. Those households interested in participating contacted the contractors in charge of sampling. Only environmental samples were collected from those homes. For both studies, environmental samples were collected from kitchen counters, kitchen taps, kitchen sinks, dishcloths, kitchen floors, refrigerators (shelves where meat was kept for thawing or storage), entryways, dog food bowls, dog eating areas, and vacuum contents. A limited number of dog food samples were obtained.

Table A presents preliminary results on the presence of quinolone and cephalosporin resistance in generic *E. coli* isolates recovered from both environmental studies. Most generic *E. coli* isolates were recovered from vacuum content samples. Quinolone-resistant isolates were found mainly in kitchen-related areas. Four isolates recovered through sampling of vacuum contents were resistant to ceftiofur but not cefoxitin, which indicated these isolates were potential carriers of genes for extended-spectrum ß-lactamases. One of these isolates was positive for the *blaTEM* gene but was negative for the *blaSHV* and *blaCMY-2* genes.

Table B presents preliminary results for the presence of quinolone and cephalosporin resistance in generic *E. coli* isolated from fecal samples obtained from various animals in the household. Quinolone resistance was only detected in fecal samples obtained from dogs (n = 21) and cats (n = 2). However, these were the species most often found in households and therefore most often sampled, thereby increasing the likelihood of detecting resistant strains. Ceftiofur resistance was only detected in isolates recovered from dog fecal samples (n = 19). No isolates had resistance to ceftiofur without resistance to cefoxitin. Of the dogs sampled, 15 were fed raw food diets (commercial or homemade) containing any of the following ingredients: chicken, beef, turkey, fish, veal, eggs, and organ meats. Three dogs received a commercial diet but were given chicken-based pet treats. One dog did not receive any raw food diet or pet treats of animal origin.

Detection of *Salmonella* spp. was less common than detection of generic *E. coli*; only 22 isolates were recovered from all environmental samples obtained. Among these, only 2 *S.* Typhimurium isolates had ceftiofur resistance, and none had resistance to the quinolones. Among fecal samples, 73 *Salmonella* isolates were recovered: 65 from dogs, 3 from birds, 3 from cats, and 1 from fish water. No quinolone resistance was identified in any of the fecal *Salmonella* isolates. Ceftiofur resistance was only detected in isolates recovered from dog fecal samples (9 of 18 *S.* Heidelberg isolates and 1 of 12 *S.* Kentucky isolates).

Ceftiofur resistance was commonly detected in generic *E. coli* and *Salmonella* isolates from dog fecal samples, whereas quinolones resistance was detected in isolates from both dog and cat fecal samples. Although the levels of resistance to quinolones and ceftiofur were low among generic *E. coli* and *Salmonella* isolates from the environment, results suggested that the environment constitutes a potential source of exposure. Household members should follow proper hygiene practices to prevent ingestion of these organisms after coming into contact with contaminated surfaces or animals as well as to prevent cross-contamination during meal preparation.

Box 3 (continued). Environmental household study.

Table A. Quinolone and cephalosporin resistance in generic *Escherichia coli* isolated from household environmental samples.

Household site	Number of samples tested	Number of isolates	Number (%) of isolates resistant to 1 or more	Number (%) of isolates quinolone-resistant			Number (%) of isolates cephalosporin-resistant
				Nalidixic acid	Ciprofloxacin MIC ≥ 4 µg/mL	Ciprofloxacin MIC ≥ 0.12 µg/mL	Ceftiofur
Counter	381	87	9 (10)	1 (1)	1 (1)	1 (1)	3 (4)
Dishcloth	379	174	17 (10)	0	0	0	0
Entryway	381	184	26 (14)	0	0	0	0
Kitchen floor	391	168	18 (11)	1 (1)	1 (1)	1 (1)	6 (4)
Fridge meat shelf	391	77	18 (23)	5 (7)	5 (7)	5 (7)	0
Kitchen sink	391	148	11 (7)	0	0	0	0
Toilet	380	111	13 (12)	0	0	0	0
Vacuum contents	370	517	77 (15)	8 (2)	7(1.4)	8 (2)	9 (2)
Dog food bowl	240	90	14 (16)	3 (3)	0	3 (3)	1 (1)
Dog eating area	243	100	11 (11)	3 (3)	0	0	0
Dog food	82	84	33 (39)	0	0	0	6 (7.1)
Sink taps	381	92	21 (23)	3 (3)	3 (3)	3 (3)	1 (1)

Table B. Quinolone and cephalosporin resistance in generic *Escherichia coli* isolated from fecal samples obtained from various animals in the household.

Animal species	Number of isolates	Number (%) of isolates resistant to 1 or more	Number (%) of isolates quinolone-resistant			Number (%) of isolates cephalosporin-resistant
			Nalidixic acid	Ciprofloxacin MIC ≥ 4 µg/mL	Ciprofloxacin MIC ≥ 0.12 µg/mL	Ceftiofur
Bird	6	0 (0)	0	0	0	0
Dog	511	189 (37)	21 (4.1)	12 (2.4)	21 (4.1)	78 (15.3)[a]
Chicken	3	0 (0)	0	0	0	0
Duck	3	2 (67)	0	0	0	0
Horse	6	0 (0)	0	0	0	0
Cat	88	15 (17)	2 (6.5)	0	1 (3.1)	0
Fish (water)	15	0 (0)	0	0	0	0
Hedgehog	3	0 (0)	0	0	0	0
Rabbit	3	3 (100)	0	0	0	0
Reptile	3	2 (67)	0	0	0	0
Rodent	8	2 (25)	0	0	0	0

[a] All isolates were also resistant to cefoxitin.

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Box 4. Retail meat sampling in Alberta – A pilot research project.

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When CIPARS Retail Meat Surveillance began in 2003, sampling was restricted to Québec and Ontario. Since then, much effort has gone into expanding the program into other provinces or regions, including full sampling in Saskatchewan and British Columbia and some preliminary sampling in Atlantic Canada. In June 2007, a retail meat research project was initiated by AAFC researchers (primary investigator, Dr. Mueen Aslam) in Lacombe, Alberta in collaboration with the Public Health Agency of Canada (CIPARS team) and AARD. This multi-year project is funded by the Alberta Livestock Industry Development Fund. The first 10 months (June 2007 to March 2008) were devoted to the collection of retail meat samples, subsequent bacterial culture of samples, and confirmation and phenotypic antimicrobial susceptibility testing of all bacterial isolates recovered. The focus of this project is shifting to the completion of phenotypic antimicrobial susceptibility testing (Fall 2008), the investigation of genetic aspects associated with antimicrobial resistance (e.g. prevalence of various resistance genes in various microorganisms isolated from the retail meat samples), and the presentation of results.

The sampling design used in this research project was identical to that used in CIPARS Retail Meat Surveillance with the exception that turkey samples were also collected from each store (in addition to ground beef, pork chops, and chicken legs, breasts, or thighs) whenever available. Samples were collected from 19 geographic regions (census divisions) on a continuous basis. Primary bacterial isolation was conducted at the Food Safety Division of AARD in Edmonton. Bacterial culture of retail samples was performed with the same meat-bacteria combinations as in CIPARS Retail Meat Surveillance, and *Enterococcus*, *Salmonella*, and generic *Escherichia coli* were isolated from turkey samples. The methods used to recover isolates from the meat samples in this project varied slightly from the CIPARS primary isolation protocols because all primary isolation was performed at the Food Safety Division of AARD, where validated, sound primary isolation protocols were already in place at the time this project began. Antimicrobial susceptibility testing for isolates of generic *E. coli* and *Enterococcus* is being performed at AAFC in Lacombe. Antimicrobial susceptibility testing and serotyping of *Salmonella* isolates is being performed at the Laboratory for Foodborne Zoonoses in Guelph, Ontario. Antimicrobial susceptibility of all isolates in this project was determined by means of microbroth dilution (Sensititre®), according to guidelines of the Clinical and Laboratory Standards Institute. A summary of the type and number of retail meat samples collected in Alberta during the sampling period (i.e. June 2007 to March 2008) as well as data on the recovery of various bacteria from these samples is provided below (Table A).

Table A. Summary of the types and numbers of retail samples collected as well as recovery rates and numbers of isolates to be submitted for antimicrobial susceptibility testing, by bacterial species; Alberta Retail Meat Research Project, June 2007 to March 2008.

Sample type	*Escherichia coli*		*Enterococcus*		*Salmonella*	
(number of sample collected)[a]	Recovery rate (%)	number of isolates	Recovery rate (%)	number of isolates	Recovery rate (%)	number of isolates
Ground beef (n = 134)	82	110	99	132	0	0
Pork (n = 133)	30	40	89	118	2	3
Chicken (n = 206)	96	198	100	206	40	83
Turkey (n = 91)	86	78	100	91	28	25

[a] At the time of writing, the numbers of samples of each commodity used to recover *Salmonella* were as follows: ground beef, 123; pork, 122; chicken, 188; and turkey, 82.

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Box 5. The effect of intramammary antimicrobial therapy at dry off on antimicrobial resistance in commensal fecal *Escherichia coli* and *Enterococcus* spp. on commercial dairy farms.

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The association of dry-cow treatment (DCT) with increased antimicrobial resistance in generic fecal *Escherichia coli* and *Enterococcus* spp. was tested in a longitudinal cohort study. Nine dairy farms in Québec and Ohio practicing selective DCT were studied from September 2005 to December 2007. Four *E. coli* isolates and 5 *Enterococcus* spp. isolates were selected from among isolates recovered from fecal samples obtained before dry-off and after subsequent calving from all cows that started and completed dry periods during study. For isolates of *E. coli* and *Enterococcus* spp., minimum inhibitory concentrations (MICs) were determined by use of microbroth dilution and the appropriate antimicrobial panels of the National Antimicrobial Monitoring System. The association of DCT with increased median MIC within cow was estimated separately for each bacterial species and antimicrobial combination with generalized estimating equation models. Effect modification of associations by location (Québec or Ohio) and antimicrobial used for DCT (cephapirin or novobiocin/penicillin G) were investigated. For fecal *E. coli* isolates, an increased MIC of ceftiofur was associated with DCT (odds ratio [OR], 1.6; 95% confidence interval [CI], 1.1 to 2.5). Overall, 153 (95%) of all *E. coli* isolates recovered during the study were susceptible to ceftiofur. The effect of DCT on increased resistance of *E. coli* to nalidixic acid was modified by the antimicrobial used (novobiocin/penicillin G; OR, 0.25; 95% CI, 0.11 to 0.55). For *Enterococcus* spp., DCT was apparently associated with a lower chance of an increase in median MICs of lincomycin, penicillin, quinupristin-dalfopristin, tetracycline, and tylosin. Additional studies are needed to further elucidate the apparent associations detected.

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Box 6. Antimicrobial resistance and aquaculture.

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The development of antimicrobial resistance (AMR) among human pathogens has become one of the biggest challenges facing the medical community in the 21st century. Many countries now have AMR surveillance networks that examine and follow AMR trends in warm-blooded animals. The bacteria of interest are primarily members of the Enterobacteriaceae and Campylobacteriaceae that can cause disease in humans. To date, the surveillance networks do not address the potential problems associated with AMR in aquatic bacterial populations in fish, aquatic food products, or the aquatic environment. Bacteria containing resistance determinants have been identified in environments receiving effluents from the aquaculture industry as well as in aquaculture and other seafood products. Therefore, it could be assumed that there is a risk of human exposure to aquatic AMR pathogens and a risk of transfer of resistance determinants from aquatic bacteria in seafood and the environment to bacteria pathogenic for humans. That degree of risk is unknown. The first step toward identifying these risks is the development of a surveillance program that addresses AMR in aquatic bacteria. To do this, standardized methods associated with bacterial isolation and antimicrobial susceptibility testing of aquatic bacteria must be developed and refined. The development of isolation methods for *Vibrio* sp., Aeromonas sp., and *Escherichia coli* from seafood was undertaken during the summer of 2007. This project will now continue with additional evaluation of AMR in isolated bacteria in collaboration with the Public Health Agency of Canada and the University of Guelph. The work involved with this segment of the project will focus on sensitivity testing of bacteria that makes use of minimum inhibitory concentration, disk diffusion, E-test, and PCR techniques.

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Box 7. Association between antimicrobial resistance and antimicrobial usage in mastitis treatment and control.

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Antimicrobial use creates selection pressure on microbes, and this pressure is potentially linked to the development of antimicrobial resistance (AMR). In dairy cattle worldwide, mastitis is the leading reason for antimicrobial use. However, information that integrates antimicrobial use and AMR profiles of common bovine mastitis pathogens is lacking in Canada.

Our research group is determining a) farm antimicrobial use, b) AMR profiles of udder pathogens, c) changes in the incidence of resistant pathogens attributable to antimicrobial use, and d) the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum β-lactamase (ESBL) *Escherichia coli* and *Klebsiella* isolates from the national cohort of dairy farms in the Canadian Bovine Mastitis Research Network.

Project update:

1) Farm antimicrobial use data collection has ended. Treatment records have been collected and will be compared with the total collection of used antimicrobial containers identified in a "garbage can audit."

2) To date, AMR profiles for 630 *S. aureus*, 220 *E. coli*, and 52 *Klebsiella* isolates have been determined, including screening for methicillin resistance and ESBLs. At the end of this study, up to 2,000 *S. aureus* isolates will be screened for methicillin resistance and up to 1,000 *E. coli* and 200 *Klebsiella* sp. isolates will be screened for ESBLs.

3) The MICs of 172 isolates have been determined to assess changes in incidence of resistant pathogens attributable to antimicrobial use. Pre- and post-treatment MIC values of 400 isolates will be used to evaluate the potential association between antimicrobial use and AMR.

4) Isolates with AMR patterns will be evaluated to determine the genetic mechanism of resistance.

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Box 8. Evaluation of the risks of shedding salmonellae and other potential pathogens by therapy dogs fed raw meat diets.

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Therapy dogs participate in animal-assisted interventions (AAIs) and, as a result, commonly interact with people who are immunocompromised. Feeding raw meat (including poultry) to therapy dogs remains controversial despite mounting evidence that raw meat is often contaminated with *Salmonella*. Our objective for this study was to determine whether consumption of raw meat influences the fecal shedding of *Salmonella* and other potential pathogens by therapy dogs. Two hundred healthy therapy dogs from Ontario and Alberta were enrolled in the study between May 2005 and November 2006. Fecal samples were collected from each dog every 2 months for 1 year. With each sample, dog owners were asked to submit information on places visited, antimicrobials used within the home, and dog health status and diet. Bacterial culture of samples was performed to isolate *Salmonella*, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci, extended-spectrum cephalosporinase *E. coli*, and *Clostridium difficile*. Twenty percent (40/200) of the dogs were reportedly fed raw meat at least once during the collection year.

The incidence rate of *Salmonella* shedding in dogs fed raw meat was 0.61 cases/dog-year, compared with 0.08 cases/dog-year in those not fed raw meat ($P < 0.001$). A generalized linear mixed model was developed to compare the odds of *Salmonella* shedding between dogs fed raw meat and those not fed raw meat, controlling for therapy dog group, repeated measures, pig ear consumption, and diarrhea in the 2 months prior to sample submission. Results of that model indicated that dogs that consumed raw meat were significantly more likely to test positive for *Salmonella* at least once during the year than dogs that did not eat raw meat (odds ratio [OR], 22.7; 95% confidence interval [CI], 3.1 to 58.8; $P < 0.001$). *Salmonella* Typhimurium, *S.* Heidelberg, and *S.* Kentucky were more common among dogs that consumed raw meat versus those that did not. Raw meat consumption was also associated with shedding extended-spectrum cephalosporinase *E. coli* (OR, 17.2; 95% CI, 9.4 to 32.3). No associations between *C. difficile*, MRSA, or vancomycin-resistant enterococci and consumption of raw meat were detected. On the basis of our results our results, we recommend that dogs fed raw meat be excluded from AAI programs, particularly when the programs involve interactions with individuals at high risk of infection. Although therapy dogs may not be representative of the general dog population, we additionally recommend that feeding of raw meat to dogs be avoided in homes of immunocompromised people.

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Box 9. CIPARS *Retail Meat Surveillance* in the Maritimes, 2007.

In an effort to expand the national scope of CIPARS *Retail Meat Surveillance*, a preliminary retail meat sampling study was initiated in the Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island) in 2007. Overall, 22 samples were collected from New Brunswick, 48 were collected from Nova Scotia, and 24 were collected from Prince Edward Island. A summary of the results from this pilot project is presented here.

Seven isolates of *Salmonella* were recovered from 32 samples of retail chicken. Four isolates were *S*. Heidelberg, 1 was *S*. I 4:r:-, 1 was *S*. Infantis, and 1 *S*. Kentucky. Only the *S*. Kentucky isolate was resistant to any of the antimicrobials tested (streptomycin and tetracycline). One *S*. Typhimurium isolate was recovered from retail pork. Isolates of *Enterococcus* and *Campylobacter* were also recovered from retail chicken purchased in the Maritimes in 2007; however, because of differences in bacterial primary isolation protocols between the laboratory performing bacterial isolation of these microorganisms and the methods of CIPARS, these data are not presented. Isolation protocols have since been harmonized and these data will be presented in the future.

Table A. Percentages of retail meat samples from the Maritimes from which selected bacteria were recovered.

Commodity	*Escherichia coli*	*Salmonella*
	Isolates recovered/sample submitted (%)	
Beef	16/31 (52)	
Chicken	29/32 (91)	7/32 (22)
Pork	12/31 (39)	1/3 (3)

Table B. Resistance to specific antimicrobials in isolates of generic *Escherichia coli* and *Salmonella* recovered from retail meat samples from the Maritimes

	Antimicrobial	*Escherichia coli*			*Salmonella*	
		Number of isolates				
		Beef	Chicken	Pork	Chicken	Pork
	Number tested	16	29	12	7	1
I	Amoxicillin-clavulanic acid	1	6			
	Ceftiofur		5			
	Ceftriaxone					
	Ciprofloxacin					
II	Amikacin					
	Ampicillin	1	11	2		
	Cefoxitin		6			
	Gentamicin		2	7		
	Kanamycin		1	2		1
	Nalidixic acid					
	Streptomycin		9	2	1	
	Trimethoprim-sulfamethoxazole	1	1	1		
III	Chloramphenicol		3	2		
	Sulfisoxazole	1	10	5		
	Tetracycline	3	15	7	1	1
IV						

[a] Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate. Values in table represent numbers of isolates.

Appendix A - Methods

A.1 Categorization of Antimicrobials Based on Importance in Human Medicine

Categories of antimicrobial drugs used in this report were taken from the Categorization of Antimicrobial Drugs Based on Importance in Human Medicine[26] of the Health Canada Veterinary Drugs Directorate (Table A.1.1).

Antimicrobials are considered of Very High Importance in Human Medicine (Category I) when they are essential for the treatment of serious bacterial infections and there is limited or no availability of alternative antimicrobials for effective treatment if resistance to the responsible agents were to emerge. Antimicrobials of High Importance in Human Medicine (Category II) consist of those that can be used to treat a variety of infections, including serious infections, and for which alternatives are generally available. Bacteria resistant to drugs of this category are generally susceptible to Category I drugs, which could be used as alternatives. Antimicrobials of Medium Importance in Human Medicine (Category III) are used for treatment of bacterial infections for which alternatives are generally available. Infections caused by bacteria resistant to these drugs can, in general, be treated with Category II or I antimicrobials.

Antimicrobials of Low Importance in Human Medicine (Category IV) are currently not used in human medicine.

Table A.1.1. Categorization of antimicrobial drugs based on importance in human medicine.

Category of importance in human medicine		Antimicrobial class
I	Very High Importance	Carbapenems Cephalosporins – Third and 4th generations Fluoroquinolones Glycopeptides Glycylcyclines Ketolides Lipopeptides Monobactams Nitroimidazoles (metronidazole) Oxazolidinones Penicillin-β-lactamase inhibitor combinations Polymyxins (colistin) Streptogramins Therapeutic agents for tuberculosis (e.g., ethambutol, isoniazid, pyrazinamide, and rifampin)
II	High Importance	Aminoglycosides (except topical agents) Cephalosporins – First and 2nd generations (including cephamycins) Fusidic acid Lincosamides Macrolides Penicillins Quinolones (except fluoroquinolones) Trimethoprim-sulfamethoxazole
III	Medium Importance	Aminocyclitols Aminoglycosides (topical agents) Bacitracins Fosfomycin Nitrofurans Phenicols Sulfonamides Tetracyclines Trimethoprim
IV	Low Importance	Flavophospholipols Ionophores

[26] Version November 30, 2006. See: http://www.hc-sc.gc.ca/dhp-mps/consultation/vet/consultations/amr_ram_hum-med_e.html. Accessed August 2009.

A.2 Sampling and Testing Methods in Humans

Sampling design and data collection

The objective of the *Surveillance of human clinical isolates* is to implement and evaluate a prospective, representative, and methodologically unified approach for monitoring temporal trends in the development of antimicrobial resistance in *Salmonella* from humans and to integrate this information with information on antimicrobial resistance from the agri-food components of CIPARS.

Hospital-based or private clinical laboratories usually culture human *Salmonella* isolates in Canada. Although reporting is mandatory through laboratory notification of reportable diseases to the National Notifiable Disease Reporting System, forwarding of *Salmonella* cultures to the provincial reference laboratory is voluntary and passive. The proportion of *Salmonella* isolates forwarded to the Provincial Public Health Laboratories (PPHLs) and Provincial Central Reference Laboratories is unknown and varies among laboratories.

Prior to 2002, PPHLs have forwarded a certain number of *Salmonella* isolates to the Enteric Diseases Program, National Microbiology Laboratory (NML), Public Health Agency of Canada (PHAC), Winnipeg, Manitoba for confirmation and subtype characterization. A letter of agreement by which provinces agreed to forward all or a subset of their *Salmonella* isolates to CIPARS was signed in 2002 by the NML, the Laboratory for Foodborne Zoonoses (LFZ) and the Centre for Food-borne, Environmental and Zoonotic Infectious Diseases of the PHAC, and the PPHLs. This agreement officially launched the *Surveillance of Human Clinical Isolates* component of CIPARS.

To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak-associated and non-outbreak-associated) received passively by PPHLs in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador were forwarded to the NML. The PPHLs in more populated provinces (British Columbia, Alberta, Ontario, and Québec) forwarded only the isolates received from the first to the 15th of each month. However, all human *S.* Newport and *S.* Typhi isolates were forwarded to the NML because of concerns of multidrug resistance and clinical importance, respectively.

The PPHLs from each province were also asked to provide a defined set of data for each forwarded isolate, including serovar name, date collected, outbreak identification (if applicable), and patient age, gender, and province of residence. Provision of patient information on travel history, antimicrobial use, hospitalization status at the time of sample collection, and date of disease onset was optional. These optional data were not usually available to the NML in 2007. Although many outbreaks are identified by PPHLs prior to isolate submission, some outbreaks are identified after the isolates are forwarded to the NML. For 2007, there was no outbreak identification information available to accompany isolates submitted to the NML.

Bacterial isolation

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

Serotyping and phage typing

In general, clinical laboratories forwarded their *Salmonella* isolates to their PPHL for identification and serotyping. Isolate identifications were confirmed by the NML when isolates received did not have a serovar name (Le Minor and Popoff, 2001) or when inconclusive results arose during phage typing.

All *Salmonella* Heidelberg, *S.* Typhimurium, *S.* Enteritidis, *S.* Hadar, *S.* Newport, *S.* Typhi, *S.* Paratyphi B, *S.* Paratyphi B var. L(+) tartrate+, *S.* Infantis, *S.* Thompson, *S.* Oranienburg, *S.* Panama, *S.* I 4,[5],12:b:-, and *S.* I 4,[5],12:i:- isolates were phage typed at the NML.

The Identification and Serotyping and the Phage Typing units at the NML have attained International Standards Organization (ISO) 17025 accreditation by the Standards Council of Canada. The Identification and Serotyping, Phage Typing, and Antimicrobial Resistance units at the NML participate in the annual Global *Salmonella* Surveillance (GSS), External Quality Assurance System of the World Health Organization, Enter-net (a European network for the surveillance of human gastrointestinal infections) proficiency program for *Salmonella*, and a strain exchange with the LFZ (*Salmonella* and *Escherichia coli*). The NML has been a strategic planning member of the World Health Organization's GSS program since 2002.

Serotyping

The O or somatic antigens of the *Salmonella* isolates were detected by use of a slide agglutination method (Ewing, 1986). The H or flagellar antigens were detected by means of a microtechnique (Shipp and Rowe, 1980) that uses microtitre plates. The antigenic formulae of Le Minor and Popoff (2001) were used to name the serovars.

Phage typing

Salmonella isolates were maintained at room temperature until typed. For typing, the standard phage typing technique described by Anderson and Williams (1956) was followed. Isolates were streaked onto nutrient agar plates and incubated at 37°C for 18 hours. One smooth colony was selected and used to inoculate 4.5 mL of phage broth (Difco™ phage broth, Difco Laboratories, Baltimore, MD; pH, 6.8), which was then incubated for 1.5 to 2 hours in a shaking water bath at 37°C to attain a bacterial growth with a turbidity equivalent to 0.5 McFarland standard. Phage agar plates (Difco™ phage agar, Difco Laboratories) were flooded with approximately 2 mL of culture medium, and the excess liquid was removed with a Pasteur pipette. Flooded plates were allowed to dry for 15 minutes at room temperature. Afterward, approximately 20 µL of each serovar-specific typing phage was used to inoculate the bacterial lawn by means of a multiple inoculating syringe method (Farmer et al., 1975). The plates were incubated at 37°C overnight, and lytic patterns were subsequently interpreted (Anderson and Williams, 1956).

Salmonella Enteritidis strains were phage typed with typing phages obtained from the International Centre for Enteric Phage Typing, Central Public Health Laboratory, Colindale, England (Ward et al., 1987). The phage-typing protocol and phages for *Salmonella* Typhimurium, developed by Callow (1959) and further extended by Anderson (1964) and Anderson and colleagues (1977), were obtained from the International Centre for Enteric Phage Typing. The *S.* Heidelberg phage typing protocol and phages were supplied by the NML (Demczuk et al., 2003). Isolates that reacted with the phages but did not conform to any recognized phage type were designated as atypical. Strains that did not react with any of the typing phages were designated as untypable.

Antimicrobial susceptibility testing

All *Salmonella* isolates of human origin were tested for antimicrobial susceptibility testing at the NML. Isolates were tested using the same antimicrobial susceptibility testing protocols as those described for agri-food *Salmonella* isolates in section A.3.

A.3 Sampling and Testing Methods in the Agri-Food Sector

Sampling design and data collection

Farm Surveillance

The objectives of the CIPARS *Farm Surveillance* component are to provide data on antimicrobial use and resistance, investigate associations between antimicrobial use and resistance, and provide data for human-health risk assessments.

Farm Surveillance is the most recent component of CIPARS and complements existing abattoir and retail sampling activities. This initiative focuses on a sentinel farm framework that provides data on antimicrobial use as well as samples obtained from farms for bacterial isolation and antimicrobial susceptibility testing. It is administered and coordinated by the Laboratory for Foodborne Zoonoses (LFZ).

In 2006, the CIPARS *Farm Surveillance* component was implemented in swine herds across the 5 major pork-producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). The swine industry was selected as the pilot commodity for development of the surveillance infrastructure because the Canadian Quality Assurance (CQA®) program has been extensively implemented by the industry, there has not been a recent outbreak of foreign animal disease in pigs.

The *Farm Surveillance* component concentrates on grower-finisher hogs. Pigs in this stage of production were chosen because of the proximity of this stage to the consumer.

Nationally, 29 veterinarians and 108 sentinel grower-finisher sites were enrolled. In each of the 5 participating provinces, the number of CIPARS sentinel sites was proportional to the national total of grower-finisher units, except in Alberta and Saskatchewan, where 10 additional sentinel herds were included. This was made possible through financial and laboratory support provided by Alberta Agriculture and Rural Development (AARD) and Saskatchewan Agriculture. The AARD also provided laboratory testing for all samples collected from the CIPARS sentinel herds in Alberta.

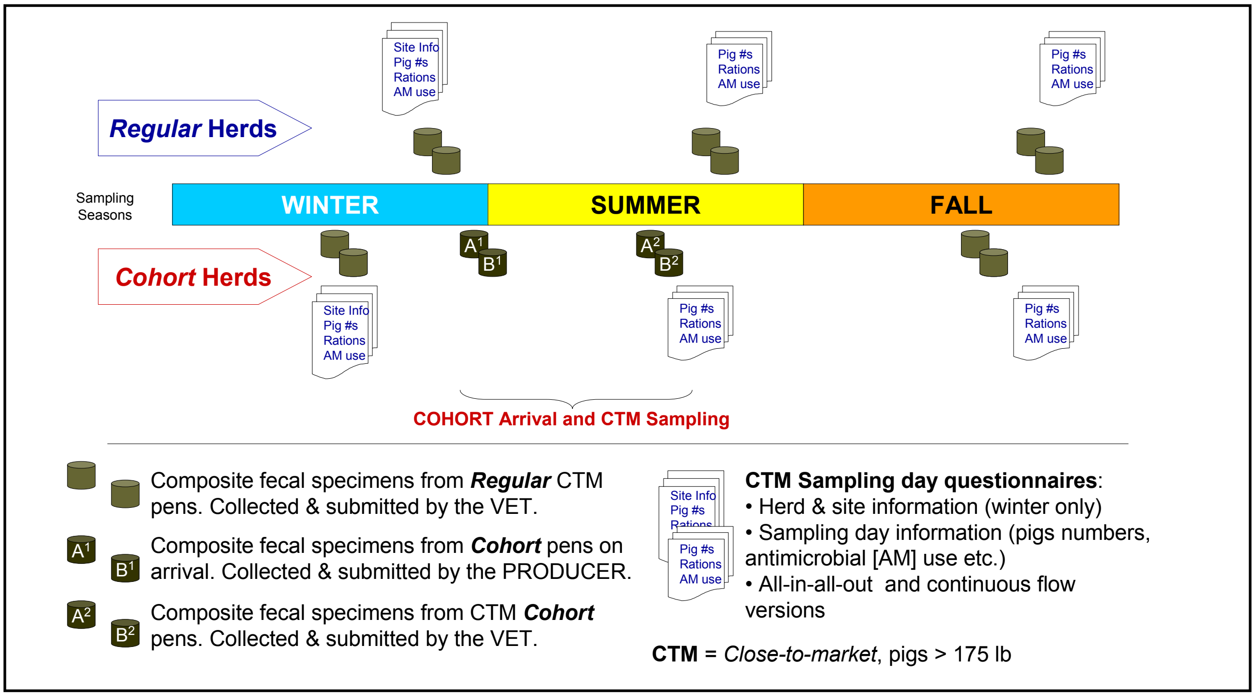
To preserve the anonymity of participating producers, herd veterinarians collected the samples and data and submitted depersonalized information to PHAC. In the case of corporate herds, 2 private supervisory veterinarians ensured confidentiality by holding the key to corporate-herd codes. This step was taken because knowing a corporate veterinarian's name could have identified the corporation associated with the herd, thereby breaking anonymity.

Veterinarians were purposively selected from the list of veterinarians practicing swine medicine in each province. Each veterinarian selected a predetermined number of sentinel farm sites by use of specific inclusion and exclusion criteria. To be included, herds were required to be CQA® validated, produce more than 2,000 market pigs per year, and be representative of the characteristics (i.e. similar production volumes and types of production systems) and geographic distribution of herds in the contractor's swine practice. Herds were excluded when they were regarded as organic with respect to animal husbandry, were fed edible residual material, or were raised on pasture. These criteria helped ensure that the herds enrolled were representative of most grower-finisher swine herds in Canada.

Pooled fecal samples were collected 3 times per year from pens of pigs that were close to market weight (Figure A.3.1). In a subset of herds, specific cohorts of pigs were sampled twice: within 6 hours after pigs entered the grow-finisher unit and again when the same pigs were close to market weight (i.e. more than 175 lb).

Antimicrobial resistance data for bacterial isolates recovered from pooled fecal samples of close-to-market pigs are presented in this report. Data are not presented for pooled fecal samples collected when pigs arrived in grower-finisher units; however, these data are available upon request. Overall prevalence estimates, which were calculated from data for arrival and close-to-market samples, are also not presented here.

Figure A.3.1. Example of sampling visits in regular and cohort swine herds over a calendar year.



Abattoir Surveillance

The objective of the CIPARS *Abattoir Surveillance* component is to provide nationally representative and valid annual antimicrobial-resistance data for bacteria isolated from animals entering the food chain. Initially, the component targeted generic *E. coli* and *Salmonella* from beef cattle, pigs, and broiler chickens. Since 2002, the component was refined to discontinue *Salmonella* isolation from beef cattle because of the low prevalence of *Salmonella* in that population. Additional change led to the inclusion of *Campylobacter* surveillance in beef cattle in late 2005.

In the *Abattoir Surveillance* component, the unit of concern (i.e. the subject of interest) was the bacterial isolate. The bacteria of interest were sampled from the cecal contents (not carcasses) of slaughtered food animals to avoid misinterpretation related to cross-contamination and to better reflect the antimicrobial resistance in bacteria that originated on the farm.

The sampling method used was designed with the expectation that, across Canada, 150 isolates of each targeted bacterial species would be recovered from each of the 3 animal species over a 12-month period. The exception to this expectation was *Campylobacter* in beef cattle, for which it was estimated that 100 isolates would be recovered over the same period. These numbers represented a balance between acceptable statistical precision and affordability (Ravel, 2001). The actual number of samples collected was derived for each species of food animal on the basis of the expected cecal prevalence of the bacteria in that animal species. For example, if the expected bacterial prevalence was 10%, then 1,500 samples would need to have been collected and submitted for bacterial isolation.

The sampling design is based on a two-stage sampling, each commodities being handled separately. The first stage consisted of random selection of federally inspected slaughterhouses, which slaughter over 90% of all food animals in Canada. The probability of an abattoir being selected was proportional to its annual slaughter volume. The second stage involved systematic selection of animals on the slaughter line. The annual number of cecal samples collected at each abattoir was proportional to its slaughter volume.

To minimize shipping costs and allow each abattoir to maintain efficiency, the annual total number of samples to be collected in each abattoir was divided by 5, resulting in the number of collection periods. For each collection period, the 5 cecal samples were collected within 5 days, at the convenience of the slaughterhouse staff, provided the 5 animals and associated samples originated from different groups of animals. Sampling from different groups was important to maximize diversity and avoid bias attributable to over representation of particular producers. Collection periods were uniformly distributed throughout the year, leading to an abattoir-specific schedule for collection of cecal contents. The uniform distribution of the collection periods avoided any bias that may have resulted from seasonal variation in bacterial prevalence and antimicrobial-susceptibility test results.

Forty-three federally inspected slaughter plants (24 poultry plants, 13 swine plants, and 6 beef cattle plants) from across Canada participated in the 2007 CIPARS *Abattoir Surveillance* component. For pigs and chickens, numbers of samples collected were based on the aforementioned expectation of 150 *Salmonella* and 150 *E. coli* isolates and the expected prevalence of *Salmonella* and *E. coli* in each animal species. For beef cattle, the number of samples collected was based the expectation of 100 *Campylobacter* and 150 *E. coli* isolates and the expected prevalence of *Campylobacter* and *E. coli* in beef. Samples were obtained according to a predetermined protocol, with modifications to accommodate various production-line configurations in the different plants. Protocols were designed to avoid conflict with carcass inspection methods, plant-specific Food Safety Enhancement Program, Health and Safety requirements, and a plant's ability to salvage viscera. They were also designed to avoid situations of potential cross-contamination. All samples were collected by industry personnel under the oversight of the Veterinarian-in-Charge of the Canadian Food Inspection Agency.

Retail Meat Surveillance

The objective of CIPARS *Retail Meat Surveillance* is to evaluate antimicrobial resistance in selected bacterial species found in retail food. Retail food represents a logical sampling point for surveillance of antimicrobial resistance because it is the endpoint of food animal production. The focus of the surveillance framework can be modified (e.g. to food commodities, bacteria, or regions) as necessary and functions as a research platform for investigation of specific questions regarding antimicrobial resistance in the agri-food sector.

As with *Abattoir Surveillance,* the unit of concern was the bacterial isolate cultured from one of the commodities of interest. In this situation, the commodities were raw meat products commonly consumed by Canadians, which originated from the 3 animal species sampled in the *Abattoir Surveillance* program. These raw meat products consisted of poultry (chicken legs or wings [skin on]), pork (chops), and beef (ground beef).

For ground beef, only samples of lean ground beef were collected in the first year of surveillance (2003); however, in 2004, the scope was widened to include systematic selection of extra-lean, lean, medium, and regular ground beef. This change was made to ensure representation of the heterogeneity of ground beef with respect to its origins (e.g. domestic vs. imported beef or fed beef cattle vs. culled dairy cattle). The meat cuts "legs or wings with skin on," "chops," and "ground beef" were also chosen on the basis of high prevalences of the targeted bacterial species within and the low purchase prices of these commodities (Ravel, 2002).

The bacteria of interest in chicken were *Campylobacter*, *Salmonella*, *Enterococcus*, and generic *E. coli*. In pork and beef, only *E. coli* were cultured and then tested for antimicrobial susceptibility given the low prevalence of *Campylobacter* and *Salmonella* in these commodities at the retail level, as determined during the early phase of the program. *Salmonella* was isolated from pork but only to provide recovery estimates for this commodity for other PHAC programs. Lastly, the presence of *Enterococcus* in beef and pork was not tested because of budgetary constraints.

The sampling protocol was designed to evaluate antimicrobial resistance in certain bacterial species that contaminate retail meat and to which Canadian consumers may subsequently be exposed. It primarily involved continuous weekly submission of samples of retail meat from randomly selected geographic areas (i.e. census divisions defined by Statistics Canada), weighted by population, in each participating province. In 2007, retail meat samples were collected in Saskatchewan, Ontario, and Québec. Some samples were also collected in British Columbia in 2007, and retail sampling in British Columbia was continued into 2008 with a higher frequency. Data from Statistics Canada were used to choose between 15 and 18 census divisions per province by means of stratified random selection. The strata were formed by use of the cumulative population quartiles from a list of census divisions in a province, sorted by population in ascending order, and are summarized as follows:

In Ontario and Québec:

- Stratum One – 10 divisions selected, with 2 sampling days per division per year
- Stratum Two – 4 divisions selected, with 5 sampling days per division per year
- Stratum Three – 2 divisions selected, with 10 sampling days per division per year
- Stratum Four – 1 division selected, with 20 sampling days per year

In Saskatchewan:

- Stratum One – 9 divisions selected, with 2 sampling days per division per year
- Stratum Two – 5 divisions selected, with 3 sampling days per division per year
- Stratum Three - 2 divisions selected, with 5 sampling days per division per year
- Stratum Four - 1 division selected, with 7 sampling days per year

In British Columbia:

- Stratum One – 10 divisions selected, with 1 sampling day per division per year
- Stratum Two – 4 divisions selected, with 3 sampling days per division per year
- Stratum Three – 1 division selected, with 20 sampling days per year.

Field workers in Ontario and Québec conducted 1 sampling day per week, and those in Saskatchewan and British Columbia conducted 1 sampling day every other week. Sampling was less frequent in Saskatchewan and British Columbia because of funding constraints, limited laboratory capacity, and a desire to avoid over-sampling at particular stores. Samples were collected on Monday or Tuesday for submission to the LFZ, Saint-Hyacinthe, Québec by Wednesday. Samples submitted from outside Québec were sent to the same laboratory via 24-hour courier. In each province, 2 census divisions were sampled on each sampling day. In each census division, 4 stores were selected prior to the sampling day, based on store type. Generally, 3 chain stores and 1 independent market or butcher shop were selected. An exception to this protocol was made in densely populated urban divisions (e.g. Toronto or Montréal), where 2 chain stores and 2 independent markets or butcher shops were sampled to reflect the presumed shopping behaviour of that subpopulation. From each store type, 1 sample of each commodity of interest was collected, for a total of 11 meat samples (4 chicken, 4 pork, and 3 beef samples) per division per sampling day.[27] When possible, specific stores were sampled only once per sampling year. Prevalence estimates were used to determine the numbers of samples to be collected, which were based on an expected yield of 100 isolates per commodity per province per year, plus 20% to account for lost or damaged samples.

In 2007, personal digital assistants (PDAs) were used to capture the following store and sample data:

- Type of store
- Number of cash registers (surrogate measure of store volume)
- "Sell-by" or packaging date
- Product origin – Canada, USA, or other country
- "May contain previously frozen meat" label – yes or no
- Final processing in store – yes, no, or unknown
- Air chilled – yes, no, or unknown (applied to chicken samples only)
- Organic – yes, no, or unknown
- Antimicrobial free – yes, no, or unknown
- Price per kilogram.

Individual samples were packaged in sealed zipper-type bags and placed in 16-L thermal coolers for transport. The ambient environmental temperature was used to determine the number of ice packs placed in each cooler (e.g. 1 ice pack for temperatures below 20ºC and 2 ice packs for temperatures 20ºC or above). In 1 or 2 coolers per sampling day, instruments for recording temperature data (Ertco Data Logger™, West Patterson, NJ, USA) were used to monitor temperatures to which samples were exposed.

[27] At 1 store in each division, the beef sample was not collected to minimize over-sampling of this commodity.

Surveillance of Animal Clinical Isolates

The objective of *Surveillance of Animal Clinical Isolates* is to detect new and/or emerging antimicrobial resistance patterns or new serovar/antimicrobial resistance pattern combinations in *Salmonella*. The *Surveillance of Animal Clinical Isolates* component of CIPARS is primarily based on veterinary diagnostic submissions collected by veterinarians and/or producers. Methods of sample collection typically varied among and within laboratories. These isolates were sent by provincial animal health laboratories across the country to the *Salmonella* Typing Laboratory (STL) at the LFZ, Guelph, Ontario. Isolates from Québec's animal health laboratories were sent to the Réseau des laboratoires de l'Institut national de santé animale, St-Hyacinthe, Québec. However, unlike the *Surveillance of Human Clinical Isolates* component, all isolates received by provincial animal health laboratories were not necessarily forwarded to the LFZ, with the exception of the provinces of Ontario and Québec. Therefore, coverage may have varied considerably among provinces.

Feed and Feed Ingredients

Data from the Feed and Feed Ingredients section were obtained from various sources including monitoring programs from the Canadian Food Inspection Agency (CFIA), provincial autorities, and industry, as well as a few isolates from passive surveillance of *Salmonella* isolates.

The CFIA collects samples of animal feed under 2 different programs: Program 15A (Monitoring Inspection – *Salmonella*) and Program 15E (Directed Inspection – *Salmonella*). Under Program 15A, feeds produced at feed mills, rendering facilities, ingredient manufacturers, and on-farm facilities are sampled and tested for *Salmonella*. Although this program makes use of a random sampling process, extra attention is paid to feeds that are more likely to have a higher degree of *Salmonella* contamination, such as those that contain rendered animal products, oilseed meals, fishmeals, grains, and mash. Program 15E targets feeds or ingredients from establishments that (i) produce rendered animal products, other feeds containing ingredients in which *Salmonella* could be a concern (e.g. oilseed meal or fishmeal), or a significant volume of poultry feed; (ii) are known to have repeated problems with *Salmonella* contamination; or (iii) have identified a *Salmonella* serotype that is highly pathogenic (e.g. Typhimurium, Enteritidis, or Newport). Program 15E is a targeted program; samples are not randomly selected.

Under both programs, all samples are collected aseptically and submitted to the Ottawa Carling Laboratory for bacterial culture and isolation. Modified semi-solid Rappaport Vassiliadis medium is used for *Salmonella* isolation. All *Salmonella* isolates are then sent to the *Salmonella* Typing Laboratory at the Laboratory for Foodborne Zoonoses, Guelph, Ontario for serotyping and phage typing (see Appendix A.3). All isolates were tested for antimicrobial susceptibility as described in Appendix A.4 for the agri-food sector.

Since 1989, *Salmonella* has been recovered from 14% (1,485/10,646) of feed samples tested under Program 15A and 17% (205/1,211) of feed samples tested under Program 15E. Specific information on how specimens were collected in other provincial or industry monitoring programs is not available.

Bacterial isolation

All samples were cultured by use of standard protocols. Most primary isolation of *E. coli, Salmonella*, *Enterococcus*, and *Campylobacter* were conducted at the LFZ, Saint-Hyacinthe. Part of the primary isolation for *Farm Surveillance* was conducted at the Agri-Food Laboratory, Alberta Agriculture and Rural Development (AARD).

Farm Surveillance

Further description of bacterial isolation methods for *Salmonella* and *E. coli* is provided next to this component in the *Abattoir Surveillance*, and for *Enterococcus* in the *Retail Meat Surveillance*.

Salmonella

Samples were pre-enriched for culture by mixing 10 g of feces with 90 mL of buffered peptone water (BPW) and incubating the mixture at 35°C for 24 hours.

Escherichia coli

One drop of the BPW mixture prepared for *Salmonella* isolation was streaked onto MacConkey agar and incubated at 35°C for 18 to 24 hours.

Enterococcus

One drop of the BPW mixture prepared for *Salmonella* isolation was streaked onto enterococcal isolation agar (Enterococcosel™ agar, BD, Mississauga, ON) and incubated at 35°C for 24 hours.

Abattoir Surveillance

Salmonella

The method used to isolate *Salmonella* was 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. This method allowed isolation of motile and viable *Salmonella* from cecal contents of broiler chickens and pigs. It was based on the ability of *Salmonella* to multiply and be motile in modified semi-solid Rappaport Vassiliadis (MSRV) medium at 42ºC. Ten grams of each pig sample was mixed with 90 mL of BPW, which served as a non-selective pre-enrichment broth. For chickens, cecal contents were weighed and BPW was added at a ratio of 1:10. The pig and chicken samples were incubated at 35ºC for 24 hours. Afterward, an MSRV plate was inoculated with 0.1 mL of the pre-enrichment broth and was incubated at 42ºC for 24 to 72 hours. Suspect colonies were screened for purity and used to inoculate triple-sugar-iron and urea agar slants. Presumptive *Salmonella* isolates were then assessed for reaction to the indole test, and their identities were verified by means of slide agglutination with Poly A-I and Vi *Salmonella* antiserum.

Escherichia coli

Generic *E. coli* was isolated from the cecal contents of broiler chickens, pigs, and beef cattle. Ten grams of each cecal sample was mixed with 90 mL of BPW. One drop of this mixture was streaked onto MacConkey agar and incubated at 35ºC for 18 to 24 hours. Suspect lactose-fermenting colonies were screened for purity and transferred onto Luria-Bertani agar. Presumptive *E. coli* colonies were assessed with Simmons citrate and indole tests. Isolates with negative indole results were identified with a test kit for identification of enteric bacteria (API® 20E system, bioMérieux Clinical Diagnostics, Marcy l'Étoile, France).

Campylobacter

For isolation of *Campylobacter* from beef cattle cecal samples, 0.1 mL of the BPW mixture prepared for isolation of *E. coli* was used. This volume was streaked onto modified cefoperazone charcoal deoxycholate agar (mCCDA) and incubated in a microaerophilic atmosphere at 42°C for 24 hours. Suspect colonies were streaked onto another mCCDA plate to obtain pure colonies and on Mueller Hinton agar supplemented with 5% sheep blood. Plates were incubated in a microaerophilic atmosphere at 42°C for 48 to 72 hours. The following tests were performed on presumptive *Campylobacter* colonies for genus identification and biochemical identification of species (*coli*, *jejuni*, or other spp.): Gram stain, oxidase, catalase, growth at 25°C, cephalothin resistance, hippurate, and indoxyl acetate.

Retail Meat Surveillance

Salmonella

One chicken leg or 2 wings were added to 225 mL of BPW. One hundred and fifty millilitres of the peptone rinse was used for isolation of *Campylobacter*, *E. coli*, and *Enterococcus*. The chicken samples were left in the remaining BPW rinse and were incubated at 35°C for 24 hours. Afterward, an MSRV plate was streaked with 0.1 mL of the incubated rinse, and the plate was incubated at 42°C for 24 to 72 hours. Suspect colonies were screened for purity and used to inoculate triple-sugar-iron and urea agar slants. Presumptive *Salmonella* isolates were assessed with the indole test, and their identities were verified by means of slide agglutination with Poly A-I and Vi *Salmonella* antiserum.

Escherichia coli

One chicken leg or 2 wings, 1 pork chop, or 25 g of ground beef was added to 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of a double-strength broth for selective identification of coliform bacteria and *E. coli* (EC broth) and incubated at 45°C for 24 hours. One loopful of the incubated mixture was streaked onto eosin methylene blue 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. Presumptive *E. coli* colonies were assessed with Simmons citrate and indole tests. Isolates with negative indole results were identified with a bacterial identification test kit (API® 20E system).

Campylobacter

One chicken leg or 2 wings were mixed with 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of double-strength Bolton broth and incubated in a microaerophilic atmosphere at 42°C for 48 hours. The incubated broth was then streaked onto an mCCDA plate and incubated in a microaerophilic atmosphere at 42°C for 24 hours. Suspect colonies were streaked onto another mCCDA plate and a Mueller Hinton plate. Plates were incubated in a microaerophilic atmosphere at 42°C for 48 to 72 hours. The following tests were performed on presumptive *Campylobacter colonies for genus identification and biochemical identification of species (coli*, *jejuni*, or other spp.): Gram stain, oxidase, catalase, growth at 25°C, cephalothin resistance, hippurate, and indoxyl acetate hydrolysis.

Enterococcus

One chicken leg or 2 wings were added to 225 mL of BPW. Fifty millilitres of the peptone rinse was mixed with 50 mL of double-strength selective broth (Enterococcosel™ broth, BD) and incubated at 35°C for 24 hours. One loopful of incubated broth was then streaked onto selective agar (Enterococcosel™ agar), and incubated at 35°C for 24 hours. Suspect colonies were screened for purity on Columbia agar with 5% sheep blood. Presumptive *Enterococcus* colonies were transferred onto Slaneth and Bartley agar and used to inoculate 3 tubes of phenol-red base broth containing 0.25% L-arabinose, 1% mannitol, or 1% α-methyl-D-glucoside. The plate and tubes were incubated at 35°C for 24 hours.

Surveillance of Animal Clinical Isolates

Salmonella

Salmonella was isolated at participating laboratories according to their standard procedures, which varied among laboratories. Most methods for detecting *Salmonella* in animal clinical isolates were similar in principle and involve pre-enrichment, selective enrichment, differential and selective plating, isolation, and biochemical and serological confirmation of the selected isolates.

Serotyping and phage typing

Salmonella isolates of agri-food origin were sent to the LFZ, Guelph, Ontario and at the Laboratoire d'épidémiosurveillance animale du Québec, St-Hyacinthe (Québec isolates) for serotyping. Phagetyping of all *Salmonella* isolates were performed by the *Salmonella* Typing Laboratory (STL) of the LFZ, Guelph, and antimicrobial susceptibility testing was performed by the LFZ, Guelph. The LFZ, Guelph is ISO/IEC 17025 accredited by the Standards Council of Canada. The STL is also designated as a Reference Laboratory for salmonellosis for the OIÉ (World Organisation for Animal Health). The STL has been a member of the Global *Salmonella* Surveillance network (GSS) of the World Health Organization (WHO) since 2000. This laboratory is listed on the GSS web page and provides yearly *Salmonella* summary data.[28] It also participates in a yearly External Quality Assurance System for *Salmonella* serotyping with other GSS member laboratories as well as yearly inter-laboratory exchange programs with the Ontario Ministry of Health, Toronto, Ontario and the National Microbiology Laboratory (NML), PHAC, Winnipeg, Manitoba. In 2003, the STL began external proficiency testing for phage typing. It successfully completed a phage typing proficiency panel provided by the NML, which originated from the Central Public Health Laboratory, Colindale, England.

Antimicrobial susceptibility testing

All *Salmonella isolates of agri-food origin were processed at the LFZ, Guelph. The majority of Enterococcus*, *Campylobacter*, and *Escherichia coli* isolates were tested by the LFZ, Saint-Hyacinthe. In most instances, only one isolate per positive sample was tested for antimicrobial susceptibility. For *Farm Surveillance*, antimicrobial susceptibility testing was performed on 3 *E. coli* isolates, 3 *Enterococcus* isolates, and 1 *Salmonella* isolate per sample. A portion of the *Enterococcus* and *Escherichia coli* isolates from *Farm Surveillance* in Alberta and Saskatchewan were processed by the Agri-Food Laboratory Branch, AARD. The LFZ Guelph, LFZ Saint-Hyacinthe, and AARD participate in external proficiency antimicrobial resistance testing for *Salmonella*, *E. coli*, and *Enterococcus*.

Salmonella, Escherichia coli, and *Enterococcus*

All *Salmonella* and *E. coli* isolates were tested for antimicrobial susceptibility with a panel of 15 antimicrobials (Table A.4. 1) and *Enterococcus* with a panel of 17 antimicrobials (Table A.4. 3). The minimum inhibitory concentration (MIC) values for *Salmonella*, *E. coli*, and *Enterococcus* were determined by means of the broth microdilution method (Clinical and Laboratory Standards Institute [CLSI] M7-A7). This method was performed with and automated system (Sensititre™ Automated Microbiology System, Trek™ Diagnostic Systems Ltd, West Sussex, England). This system is a commercially available broth dilution technique that makes use of dehydrated antimicrobials in the wells of microtitre plates. The CMV1AGNF (Sensititre™, Trek™ Diagnostic Systems) susceptibility plates of the National Antimicrobial Monitoring System (NARMS) were used for *E. coli* and *Salmonella*, whereas the CMV2AGPF plates were used for *Enterococci*.

Isolates were streaked onto a Mueller Hinton agar (or Columbia blood agar or Mueller Hinton blood agar) plate and incubated in an inverted position at 37°C (NML) or 35°C (LFZ Guelph and LFZ Saint-Hyacinthe) for 18 to 24 hours to obtain isolated colonies. One colony was chosen from the plate and re-streaked onto agar plates for growth. The agar plates were subsequently incubated at 37°C (NML) or 35°C (LFZ Guelph and LFZ Saint-Hyacinthe) for 18 to 24 hours. A 0.5-McFarland suspension of bacterial growth was prepared by transferring colonies from the agar plates into 5.0 mL of sterile, demineralized water and suspending them in the liquid by use of a vortex machine. Ten microlitres of the water-bacterial suspension was transferred to a tube containing 10 mL of Mueller Hinton broth (MHB) and mixed with a vortex mixer. The MHB suspension was dispensed into plates at 50 µL per well. The plates were sealed with adhesive plastic sheets and incubated for 18 hours at 37°C (NML) or 35°C (LFZ Guelph and LFZ Saint-Hyacinthe). Detection of possible vancomycin-resistant *Enterococci* required 6 more hours of incubation for a total of 24 hours.

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[28] See: http://www.who.int/salmsurv/en. Accessed August 2009.

After incubation, the CMV1AGNF plates were read and interpreted with an automated reading and incubation system (ARIS®, Trek™ Diagnostic Systems Ltd), whereas the CMV2AGPF plates were read using the manual reader (Sensititre Sensitouch™, Trek™ Diagnostic Systems). In accordance with standards set by the CLSI (CLSI M100-S18), *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 CMV1AGNF susceptibility panels. *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, and *Enterococcus faecalis* ATCC 51299 were used as quality control organisms for *Enterococcus* antimicrobial susceptibility testing.

Campylobacter

All *Campylobacter* were tested for antimicrobial susceptibility with a panel of 9 antimicrobials (Table A.4. 2).The MIC values for isolates of *Campylobacter* were determined by means of the broth microdilution method (CLSI M7-A7). Antimicrobial susceptibility testing was performed with NARMS CAMPY susceptibility panels (Sensititre™). The colonies were streaked onto Mueller Hinton agar plates with 5% sheep blood and incubated in a microaerophilic atmosphere at 42°C for 24 hours. A 0.5-McFarland suspension of bacterial growth was prepared by transferring selected bacterial colonies into a tube containing 5 mL of MHB and mixing the tube contents with a vortex mixer for at least 10 seconds. Ten seconds later, 10 µL of the MHB mixture was transferred into a tube containing 11 mL of MHB with laked horse blood and mixed for 10 seconds. The MHB mixture was dispensed into plates at 100 µL per well. The plates were sealed with adhesive plastic sheets and incubated in a microaerophilic atmosphere at 42°C for 24 hours. *Campylobacter jejuni* ATCC 33560 was used as quality control organism. The MIC values obtained were compared with those of CLSI standards (CLSI M45-A).

A.4 Antimicrobial Resistance Data Analysis

Human and agri-food isolates

Data were analyzed with statistical software programs (SAS® 9.1, SAS Institute Inc., Cary, NC, USA; Stata® 8, Stata Corp., College Station, TX, USA) and a spreadsheet application (Microsoft® Excel 2000, Microsoft Corp., Redmond, WA, USA). All figures were generated with the spreadsheet application (Microsoft® Excel 2000). Exact confidence intervals were computed by use of the BINOMIAL statement in PROC FREQ (SAS® 9.1) and an alpha level of 0.05. When the prevalence was 0%, an alpha level of 0.1 was used instead.

The percentage of isolates with resistance to antimicrobials was defined as the number of isolates resistant divided by the total number of isolates tested for each antimicrobial. The breakpoints used for the interpretation of antimicrobial susceptibility results are listed in Table A.4. 1,Table A.4. 2, and Table A.4. 3.

The number of antimicrobials in each resistance pattern was calculated by summing the number of antimicrobials tested resistant for each isolate.

For *Farm Surveillance*, *Abattoir Surveillance,* and *Retail Meat Surveillance* components, the recovery rate was defined as the number of positive culture divided by the total number of samples submitted.

For the human incidence data, the number of cases of in which a particular *Salmonella* serovar was detected per 100,000 inhabitant-years in each province was calculated by dividing the total number of isolates of each serovar received by CIPARS in each province by the population of that province (Statistics Canada post-census population estimates, Jan. 1, 2007), multiplied by 100,000. The national estimates for all serovars except *S.* Typhi and *S.* Newport were calculated as follows. In provinces for which isolates were submitted during the first 15 days of the month, the number of isolates resistant and the total number of submitted isolates were multiplied by 2 each month. Numbers of isolates resistant (estimated value in larger provinces or actual value in smaller provinces) for all provinces were summed to obtain the total estimated number of isolates resistant. Total numbers of isolates submitted (estimated value in larger provinces or actual value in smaller provinces) for all provinces were summed to obtain the total estimated number of submissions. Finally, the total estimated number of isolates resistant was divided by the total estimated number of submissions for each antimicrobial tested to obtain a national estimate of resistance for each antimicrobial and each serovar.

Temporal analyses were performed for selected antimicrobials. As often as possible, only 1 antimicrobial per antimicrobial class was selected among those antimicrobials commonly used in the agri-food and/or human sectors. Some antimicrobials were excluded from the temporal analyses for the following reasons:

- There was a low prevalence of bacterial isolates resistant to the antimicrobial, and other antimicrobials could be used to provide a surrogate measure of resistance or intermediate susceptibility (e.g. nalidixic acid for ciprofloxacin or ceftiofur for ceftriaxone).
- The rejected antimicrobial showed cross-resistance with another antimicrobial selected (e.g. amoxicillin-clavulanic acid and ceftiofur).
- The antimicrobial has been banned for use in the agri-food sector, and resistance to this drug is maintained because of the use of another drug (e.g. chloramphenicol).

A logistic regression model was developed, with year as an independent categorical variable. Data were analyzed with commercial software (Stata 9.1®; or R version 2.2.1, R Foundation for Statistical Computing, Vienna, Austria). Firth's penalized maximum likelihood estimation was performed (R version 2.2.1) when data separation (1 or more zero cells in the contingency table) was encountered. In most situations, the year 2003 was selected as the baseline period; therefore, comparisons between 2003 and 2007 were performed. Comparisons between 2004 and 2007 were also performed for resistance to ampicillin and ceftiofur in *E. coli* and *Salmonella* isolated from chicken samples to assess changes in antimicrobial resistance after the early 2005 voluntary withdrawal of ceftiofur by Québec chicken hatcheries. The year 2004 was also used as a reference for temporal comparisons of ceftiofur and ampicillin resistance in human *S.* Heidelberg because *S.* Heidelberg in humans are mainly of chicken origin. For analyses of temporal variations in in retail data from Saskatchewan, 2005 was used as the comparison year because this was the first year of CIPARS retail surveillance in that province. Values of $P \leq 0.05$ were considered significant for all analyses.

Farm Surveillance

The bacterial species, serovar, and minimum inhibitory concentration (MIC) data were maintained in a relational database (Microsoft® Access, Microsoft Corp.). Intermediate MIC values were categorized as susceptible for all analyses.

Descriptive analyses were conducted with commercially available software (Microsoft® Excel 2003, Microsoft Corp.). More complex statistical analyses were performed to account for clustering of antimicrobial resistance within herds through generalized estimating equations (PROC GENMOD, SAS® 9.1). All statistical models had a binary outcome, logit-link function, and an exchangeable correlation structure.

Null binomial response models were used to estimate the prevalence of resistance to each antimicrobial. From each model, the intercept ($ß_0$) and 95% confidence intervals were used to calculate population-average prevalence estimates with the formula $[1 + \exp(-\beta_0)]^{-1}$.

Antimicrobial susceptibility breakpoints

Table A.4.1. Breakpoints in antimicrobial susceptibility of *Salmonella* and *Escherichia coli* isolates; CMV1AGNF plate, 2007.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Amoxicillin-clavulanic acid	1.0/0.5 – 32/16	≤ 8/4	16/8	≥ 32/16
	Ceftiofur	0.25 – 8	≤ 2	4	≥ 8
	Ceftriaxone	0.25 – 64	≤ 8	16-32	≥ 64
	Ciprofloxacin	0.0156 – 4	≤ 1	2	≥ 4
II	Amikacin	0.5 – 32	≤ 16	32	≥ 64
	Ampicillin	1 – 32	≤ 8	16	≥ 32
	Cefoxitin	0.5 – 32	≤ 8	16	≥ 32
	Gentamicin	0.25 – 16	≤ 4	8	≥ 16
	Kanamycin	8 – 64	≤ 16	32	≥ 64
	Nalidixic acid	0.5 – 32	≤ 16	-	≥ 32
	Streptomycin[b]	32 – 64	≤ 32	-	≥ 64
	Trimethoprim-sulfamethoxazole	0.12/2.38 – 4/76	≤ 2/38	-	≥ 4/76
III	Chloramphenicol	2 – 32	≤ 8	16	≥ 32
	Sulfisoxazole	16 – 512	≤ 256	-	≥ 512
	Tetracycline	4 – 32	≤ 4	8	≥ 16
IV					

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate. S = Susceptible. I = Intermediate susceptibility. R = Resistant.

[a] CLSI M100-S16 Table 2A. M7-A6-MIC Testing section.

[b] No Clinical and Laboratory Standards Institute interpretive criteria for Enterobacteriaceae were available for this antimicrobial. Breakpoints were based on the distribution of minimum inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

Table A.4.2. Breakpoints in antimicrobial susceptibility of *Campylobacter* isolates; CAMPY plate, 2007.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Ciprofloxacin	0.015 – 64	≤ 1	2	≥ 4
	Telithromycin[b]	0.015 – 8	≤ 4	8	≥ 16
II	Azithromycin[b]	0.015 – 64	≤ 2	4	≥ 8
	Clindamycin[b]	0.03 – 16	≤ 2	4	≥ 8
	Erythromycin	0.03 – 64	≤ 8	16	≥ 32
	Gentamicin[b]	0.12 – 32	≤ 2	4	≥ 8
	Nalidixic acid[b]	4 – 64	≤ 16	32	≥ 64
III	Florfenicol[bc]	0.03 – 64	≤ 4	-	-
	Tetracycline	0.06 – 64	≤ 4	8	≥ 16
IV					

Roman numerals I to IV indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate. S = Susceptible. I = Intermediate susceptibility. R = Resistant.

[a] CLSI M45.

[b] No Clinical and Laboratory Standards Institute interpretive criteria for *Campylobacter* were available for this antimicrobial. Breakpoints were based on the distribution of minimum inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

[c] No resistance breakpoint defined at time report was prepared.

Table A.4.3. Breakpoints in antimicrobial susceptibility of *Enterococcus* isolates; CMV2AGPF plate, 2007.

	Antimicrobial	Range tested (μg/mL)	Breakpoints[a] (μg/mL)		
			S	I	R
I	Ciprofloxacin	0.12 – 4	≤ 1	2	≥ 4
	Daptomycin[b] (cyclic lipopeptide)	0.5 – 16	≤ 4	-	-
	Linezolid (oxazolidinones)	0.5 – 8	≤ 2	4	≥ 8
	Quinupristin-dalfopristin (streptogramins)	1 – 32	≤ 1	2	≥ 4
	Tigecycline[c]	0.015 – 0.5	≤ 0.25	0.5	≥ 1
	Vancomycin	0.5 – 32	≤ 4	8-16	≥ 32
II	Erythromycin	0.5 – 8	≤ 0.5	1-4	≥ 8
	Gentamicin (high-level)	128 – 1,024	≤ 500	-	> 500
	Kanamycin[a](high-level)[b]	128 – 1,024	≤ 512	-	≥ 1,024
	Lincomycin[b]	1 – 32	≤ 2	4	≥ 8
	Penicillin	0.5 – 16	≤ 8	-	≥ 16
	Streptomycin (high-level)[b]	512 – 2,048	≤ 1,000	-	> 1,000
	Tylosin[b]	0.25 – 32	≤ 8	16	≥ 32
III	Chloramphenicol	2 – 32	≤ 8	16	≥ 32
	Nitrofurantoin	2 – 64	≤ 32	64	≥ 128
	Tetracycline	4 – 32	≤ 4	8	≥ 16
IV	Flavomycin[b]	1 – 16	≤ 8	16	≥ 32

Roman numerals I to V indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate. S = Susceptible. I = Intermediate resistance. R = Resistant.

[a] CLSI M100-S16 Table 2D. M7-A6-MIC Testing section.

[b] No Clinical and Laboratory Standards Institute (CLSI) interpretive criteria for *Enterococcus* were available for this antimicrobial. Breakpoints were based on the distribution of minimum inhibitory concentrations and were harmonized with those of the National Antimicrobial Resistance Monitoring System.

[c] Based on the resistance breakpoint from the European Committee on Antimicrobial Susceptibility Testing because no interpretative criteria were available from CLSI for tigecycline.

A.5 Antimicrobial Use Data Collection and Analysis

Humans

CompuScript

Canadian CompuScript (CCS) measures the number of prescriptions and the number of units of product dispensed by the pharmacist to the consumer in Canada. Data fields include product name (including manufacturer), form, and strength; province; and the number of prescriptions, units of product, and dollars spent by month for each year.

The sampling frame (or "universe") for this dataset in 2007 consisted of approximately 7,980 pharmacies, covering nearly all retail pharmacies in Canada, excluding those in the Yukon, Northwest Territories, and Nunavut. The company Intercontinental Medical Statistics (IMS) Health uses a method of geospatial projection that creates projection factors for application to all non-participating stores on the basis of the number of stores in the area, distance between stores, and store size. In 2007, an average of 5,092 stores was included. The projection factor is used to extrapolate the number of prescriptions dispensed in the stores actually sampled to that of the "universe" (7,980 pharmacies).

Drugs were classified and defined daily doses (DDDs) were determined according to the Anatomical Therapeutic Chemical (ATC) classification system (Table A.5. 1). Temporary DDDs (not yet approved but posted on the World Health Organization Web site) were used when available. For pediazole, the DDD for erythromycin ethyl succinate (2 g) was used. For oral administration of penicillin G, the DDD for benzilpenicillin by parenteral route (3.6 g) was used. Drugs with no DDDs were also excluded, including trisulfaminic (drug discontinued in 2001; only a total of 832,384 extended units dispensed in 2000).

Although no hospital pharmacies participate in the CCS program, CCS data include a small volume of antimicrobials administered 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 common to include these drugs in this analysis. Consequently, the 2007 report describes only orally administered drugs dispensed by only retail pharmacies. Only information regarding drugs of ATC group J01 (antimicrobials for systemic use) were retained in the analysis. Information regarding orally administered vancomycin (ATC group A07AA) was included in the analysis under class J01XA.

The total amount of active ingredient was obtained by multiplying the number of extended units (real or corrected) by the strength of the product in grams. In the situation of combination drugs, the active ingredients of all antimicrobial components of the combination drugs were summed to obtain the total number of active ingredients. However, the amount of active ingredient used in the calculation of the total number of DDDs for combination drugs only included the molecules from which the DDDs were derived. For example, for drugs composed of trimethoprim-sulfamethoxazole, only the total number of grams of sulfamethoxazole was used to compute the number of DDDs.

The total number of DDDs per 1,000 inhabitant-days for a given year was obtained by summing all DDDs for each ATC class and each year. This number was further divided by the size of the population during that year in thousands, divided by the number of days in that year (365 or 366). The total number of prescriptions and total cost per 1,000 inhabitants was obtained by dividing the total number of prescriptions or the total cost by the population size in thousands for each year. Population data were obtained from updated and preliminary post-census estimates, based on the results of the 2001 Census. Census counts were adjusted for net under-coverage (Statistics Canada).

In the 2002 and 2003 CIPARS reports, methenamine and linezolid were classified under "Other antimicrobials." As of 2004, they have been reported separately to harmonize with reports from other surveillance programs such as the Danish Integrated Antimicrobial Resistance Monitoring and Research Programme. The use of metronidazole (under J01XD imidazole) was added in 2005. Data from metronidazole could not be extracted at the time of analysis for year 2000. That information is therefore missing from the tables and is not included in any totals for year 2000.

Table A.5.1. List of antimicrobials from the CompuScript database for each ATC[29] class.

	ATC code	ATC class	Antimicrobial
I	J01CR	Combinations of penicillins, including β-lactamase inhibitors	Amoxicillin-clavulanic acid
	J01DD	Third generation cephalosporins	Cefixime
	J01MA	Fluoroquinolones	Ciprofloxacin, gatifloxacin, grepafloxacin, levofloxacin, moxifloxacin, norfloxacin, ofloxacin, trovafloxacin
	J01XA	Glycopeptides	Vancomycin
	J01XD	Imidazole	Metronidazole
	J01XX	Linezolid	Linezolid
II	J01CA	Penicillins with extended spectrum	Amoxicillin, ampicillin, bacampicillin, pivampicillin, pivmecillinam
	J01CE	β-lactamase sensitive penicillins	Penicillin G, penicillin V
	J01CF	β-lactamase resistant penicillins	Cloxacillin, dicloxacillin, flucloxacillin
	J01DB	First generation cephalosporins	Cefadroxil, cephalexin, cephradine
	J01DC	Second generation cephalosporins	Cefaclor, cefprozil, cefuroxime axetil
	J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	Sulfadiazine-trimethoprim, sulfamethoxazole-trimethoprim
	J01FA	Macrolides	Azithromycin, clarithromycin, erythromycin, spiramycin, telithromycine
	J01FF	Lincosamides	Clindamycin, lincomycin
	J01GB	Aminoglycosides	Neomycin
	J01MB	Other quinolones	Nalidixic acid
	J01RA	Sulfonamide combinations, excluding trimethoprim	Erythromycin-sulfisoxazole
	J01XC	Steroid antibacterials	Fusidic acid
III	J01AA	Tetracyclines	Demeclocycline, doxycycline, minocycline, tetracycline
	J01BA	Amphenicols	Chloramphenicol
	J01EA	Trimethoprim and derivatives	Trimethoprim
	J01EB	Short-acting sulfonamides	Sulfamethizole, sulfapyridine, sulfisoxazole
	J01EC	Intermediate-acting sulfonamides	Phenazopyridine-sulfamethoxazole, sulfadiazine, sulfamethoxazole
	J01XE	Nitrofuran derivatives	Nitrofurantoin
	J01XX	Fosfomycin	Fosfomycin
NC	J01XX	Methenamine	Methenamine, methenamine-sodium-tartaric acid

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NC = Not classified.

Food animals

Farm Surveillance in Pigs

Sentinel herd data were collected through questionnaires completed by veterinarians, owners, or managers of the herds. The questionnaires captured information on antimicrobial use within each herd, health status of pigs, and farm characteristics. In order to accurately describe different management systems, the survey structure varied slightly depending on whether continuous flow or all-in-all out management was used.

Antimicrobial use data for the grower-finisher phase of production were collected three times per year from participating herds. No data on individual pigs were collected. Herd owners/managers were asked about antimicrobial use in feed, and water, or by injection. Data were collected on each diet fed to each population of interest, including diets that contained no antimicrobials. Because all pigs in each population of interest were exposed to the same diets, inventory data were used to determine the number of pigs exposed to antimicrobials through feed. Diet-specific data included weight of the pigs at the start and end of the diet and duration of

[29] World Health Organization Collaborating Center for Drug Statistics Methodology. See http://www.whocc.no/atcddd. Accessed August 2009.

exposure and tonnes consumed for each diet. The following additional information was collected for diets containing antimicrobials: active ingredient(s), antimicrobial concentration(s), and reason(s) for antimicrobial use (categories included enteric disease, lameness, respiratory disease, disease prevention, growth promotion, and other). Exposure to antimicrobials though water was described by the active ingredient(s) of the drug(s), weight of the pigs at the start and end of exposure, duration of exposure, number of pigs exposed, and reason(s) for antimicrobial use. Data collected on antimicrobial administration through injection included active ingredient(s) of the drug(s), the number of pigs exposed, and the reason(s) for antimicrobial use.

Antimicrobial exposures were summarized for each herd. An exposure was defined as any reported use of an active ingredient by a given administration route in 2007. Data were described by exposure to an active ingredient by a given administration route, as well as by exposure to an active ingredient by any administration route. These exposures were summarized by antimicrobial class (Giguère et al., 2006).

Data regarding the health status of the population of interest were collected (via the questionnaire) at the time each set of samples was collected (Appendix A.3). Information about the health status of the breeding animals that supplied pigs for the sentinel herds was collected annually. No data on the health status of pigs at other production stages were collected. For each disease, information was collected at the herd level regarding the diagnostic method(s) used and current disease status. Status for a given disease was reported as positive or negative on the basis of clinical signs, post-mortem findings, and/or laboratory results. In addition, data on vaccination history were also collected for use in future analyses.

Health-status data were summarized separately for grower-finisher and breeding pigs in each herd. Health status was designated as "disease positive" when a given disease was reported at any time during 2007. If more than 1 breeding herd supplied pigs for the sentinel herd, the breeding herd was considered positive for a given disease when any of the breeding herds that supplied pigs to that sentinel herd were positive for the disease.

Data were entered into a database, and all descriptive statistics were obtained with commercially available software (Microsoft Excel® 2003 and Microsoft Access® 2003, Microsoft Corp., Redmond, WA, USA; and Intercooled Stata® version 9.2, Stata Corp., College Station, TX, USA).

Appendix B - Additional Tables

The following information are important for the interpretation of tables presenting results on the distribution of minimum inhibitory concentrations (MIC; Appendix B.1 and B. 2).

- Roman numerals I to IV indicate the ranking of human medicine importance as outlined by the Veterinary Drugs Directorate.
- The unshaded fields indicate the range tested for each antimicrobial in the plate configuration.
- Bold red numbers indicate the percentage of isolates that were resistant to the antimicrobial according to the predefined resistance breakpoint.
- Numbers to the right of the highest concentration in the tested range (i.e. bold red numbers in shaded fields) represent the percentage of isolates with growth in all wells within the tested range, indicating that the actual MICs were greater than the tested range of concentrations.
- Numbers at the lowest concentration in the tested range (i.e. blue numbers at the far left in unshaded fields) represent the percentage of isolates susceptible to the antimicrobial at the indicated or lower concentrations.
- Solid bars represent resistance breakpoints.
- Dotted bars represent susceptibility breakpoints.
- MIC 50 = MIC at which 50% of isolates were inhibited.
- MIC 90 = MIC at which 90% of isolates were inhibited.
- %R = Percentage of isolates that were resistant.

B.1 Antimicrobial Resistance in Humans

Table B.1.1. Distribution of *Salmonella* isolates from humans, by patient age and province; *Surveillance of Human Clinical Isolates*, 2007.

Age (year)	Number (%) of isolates	Province	Number (%) of isolates
Less than 5	365 (11)	British Columbia	382 (12)
5 to 12	310 (9)	Alberta	397(12)
13 to 17	155 (5)	Saskatchewan	120 (4)
18 to 29	532 (16)	Manitoba	208 (6)
30 to 49	650 (20)	Ontario	1482 (45)
50 to 69	490 (15)	Québec	451 (14)
70 and more	241 (7)	Nova Scotia	85 (3)
Not specified	564 (17)	New Brunswick	130 (4)
		Prince Edward Island	17 (< 1)
		Newfoundland and Labrador	36 (1)
otal	**3,308 (100)**		**3,308 (100)**

Table B.1.2. Distribution of isolates of primary human *Salmonella* serovars from humans, by source; *Surveillance of Human Clinical Isolates*, 2007.

Specimen source	Number (%) of isolates							
	Enteritidis	Heidelberg	Newport	Paratyphi A and B	Typhi	Typhimurium	Other serovars	Total
Stool	731 (80)	240 (75)	103 (81)	9 (20)	26 (17)	559 (85)	784 (72)	2,452 (74)
Blood	23 (2)	22 (7)		20 (44)	99 (63)	17 (3)	26 (2)	207 (6)
Urine	17 (2)	11 (3)	6 (5)	2 (4)	2 (1)	14 (2)	52 (5)	104 (3)
Abscess							1 (< 1)	1 (< 1)
Anatomy part	1 (< 1)		1 (1)		1 (1)		3 (< 1)	6 (< 1)
Other body fluid	2 (< 1)				1 (1)	1 (< 1)	2 (< 1)	6 (< 1)
Unknown	136 (15)	46 (14)	17 (13)	14 (31)	27 (17)	67 (10)	225 (21)	532 (16)
Total	**910 (100)**	**319 (100)**	**127 (100)**	**45 (100)**	**156 (100)**	**658 (100)**	**1,093 (100)**	**3,308 (100)**

Table B.1.3. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* Enteritidis isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	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	> 256
I	Amoxicillin-clavulanic acid	910	≤ 1	≤ 1	0.1							91.4	6.6	0.1	1.6	0.1	0.1				
	Ceftiofur	910	1	1	0.1				0.4		4.8	93.2	1.3	0.1		0.1					
	Ceftriaxone	910	≤ 0.25	≤ 0.25	0.1					99.9									0.1		
	Ciprofloxacin	910	≤ 0.015	0.25	0.0	66.0	14.5	0.9	5.4	12.6	0.4	0.1									
II	Amikacin	910	1	2	0.0						15.1	70.7	13.2	0.9	0.1	0.1					
	Ampicillin	910	≤ 1	2	1.9							82.1	15.3	0.4	0.3			1.9			
	Cefoxitin	910	2	2	0.2							3.4	86.9	8.8	0.4	0.2	0.1	0.1			
	Gentamicin	910	≤ 0.25	0.50	0.4					80.5	17.7	1.1	0.2			0.3	0.1				
	Kanamycin	910	≤ 8	≤ 8	0.5										99.2	0.2		0.2	0.3		
	Nalidixic acid	910	4	> 32	18.4						0.2	0.2	24.0	54.5	2.3	0.4	0.1	18.2			
	Streptomycin	910	≤ 32	≤ 32	0.8												99.2	0.1	0.7		
	Trimethoprim-sulfamethoxazole	910	≤ 0.12	≤ 0.12	0.7				93.2	5.9	0.1	0.1			0.7						
III	Chloramphenicol	910	4	8	0.4								0.7	63.6	34.8	0.4		0.4			
	Sulfisoxazole	910	64	128	1.3											3.2	37.3	43.4	14.2	0.7	1.3
	Tetracycline	910	≤ 4	≤ 4	6.4									93.2	0.4	0.1	0.2	6.0			
IV																					

Table B.1.4. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* Heidelberg isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	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	> 256
I	Amoxicillin-clavulanic acid	319	≤ 1	32	15.0							67.7	2.2	0.3	6.9	7.8	7.2	7.8			
	Ceftiofur	319	1	> 8	15.0						22.6	61.1	0.9	0.3	0.6	14.4					
	Ceftriaxone	319	≤ 0.25	16	0.3					84.3		0.3	0.3		0.3	10.3	4.1	0.3			
	Ciprofloxacin	319	≤ 0.015	≤ 0.015	0.0	97.2	1.6	0.6		0.6											
II	Amikacin	319	1	2	0.0						0.6	65.2	28.8	5.0	0.3						
	Ampicillin	319	≤ 1	> 32	30.1							66.1	2.8	0.3	0.6			30.1			
	Cefoxitin	319	2	> 32	14.7							20.7	56.4	7.8		0.3	3.1	11.6			
	Gentamicin	319	≤ 0.25	0.50	2.5					58.0	38.6	0.9				0.6	1.9				
	Kanamycin	319	≤ 8	≤ 8	1.6										97.5	0.6	0.3		1.6		
	Nalidixic acid	319	4	4	0.6								16.9	81.5	0.9			0.6			
	Streptomycin	319	≤ 32	64	10.3												89.7	6.6	3.8		
	Trimethoprim-sulfamethoxazole	319	≤ 0.12	0.25	0.9				86.5	11.3			1.3	0.3	0.6						
III	Chloramphenicol	319	8	8	0.6									23.8	74.6	0.9	0.3	0.3			
	Sulfisoxazole	319	32	64	5.3											20.4	52.4	18.8	2.5	0.6	5.3
	Tetracycline	319	≤ 4	≤ 4	6.9									92.5	0.6		0.6	6.3			
IV																					

Table B.1.5. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* Newport isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	n	MIC Percentiles MIC 50	MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	127	≤ 1	≤ 1	3.1							90.6	3.9		2.4		0.8	2.4			
	Ceftiofur	127	1	1	3.1						19.7	77.2				3.1					
	Ceftriaxone	127	≤ 0.25	≤ 0.25	1.6					96.9							1.6	1.6			
	Ciprofloxacin	127	≤ 0.015	≤ 0.015	0.0	92.1	4.7		0.8	1.6	0.8										
II	Amikacin	127	1	2	0.0						2.4	48.8	45.7	2.4	0.8						
	Ampicillin	127	≤ 1	2	4.7							89.8	4.7		0.8			4.7			
	Cefoxitin	127	2	4	3.1							5.5	81.1	10.2				3.1			
	Gentamicin	127	0.50	0.50	0.0					38.6	59.8	1.6									
	Kanamycin	127	≤ 8	≤ 8	1.6										98.4				1.6		
	Nalidixic acid	127	4	4	1.6								36.2	61.4	0.8			1.6			
	Streptomycin	127	≤ 32	≤ 32	4.7												95.3	1.6	3.1		
	Trimethoprim-sulfamethoxazole	127	≤ 0.12	0.25	2.4				88.2	9.4					2.4						
III	Chloramphenicol	127	4	8	4.7									83.5	11.8		0.8	3.9			
	Sulfisoxazole	127	64	256	7.9											0.8	22.0	51.2	15.0	3.1	7.9
	Tetracycline	127	≤ 4	≤ 4	8.7									91.3		0.8	1.6	6.3			
IV																					

Table B.1.6. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* Paratyphi A and *S.* Paratyphi B isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	n	MIC Percentiles MIC 50	MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	45	2	2	0.0							31.1	62.2	2.2	2.2	2.2					
	Ceftiofur	45	1	1	0.0						2.2	95.6	2.2								
	Ceftriaxone	45	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	45	0.50	0.50	0.0	22.2	6.7	2.2		2.2	66.7										
II	Amikacin	45	0.50	1	0.0						75.6	20.0	4.4								
	Ampicillin	45	2	2	4.4							13.3	80.0	2.2				4.4			
	Cefoxitin	45	4	8	0.0								8.9	64.4	26.7						
	Gentamicin	45	≤ 0.25	0.50	0.0					88.9	11.1										
	Kanamycin	45	≤ 8	≤ 8	0.0										100.0						
	Nalidixic acid	45	> 32	> 32	68.9								6.7	24.4				68.9			
	Streptomycin	45	≤ 32	≤ 32	4.4												95.6	2.2	2.2		
	Trimethoprim-sulfamethoxazole	45	≤ 0.12	0.25	2.2				68.9	24.4	4.4				2.2						
III	Chloramphenicol	45	8	8	4.4									6.7	88.9			4.4			
	Sulfisoxazole	45	32	64	4.4											15.6	62.2	15.6	2.2		4.4
	Tetracycline	45	≤ 4	≤ 4	4.4									95.6			2.2	2.2			
IV																					

Table B.1.7. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* Typhi isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	n	MIC Percentiles MIC 50	MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	156	≤ 1	8	0.0							78.2	1.3	2.6	16.7	1.3					
	Ceftiofur	156	0.50	1	0.0						73.1	26.9									
	Ceftriaxone	156	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	156	0.25	0.25	1.3	17.3	0.6	3.8	7.7	66.0	2.6		0.6		1.3						
II	Amikacin	156	1	2	0.0						9.6	74.4	14.7	1.3							
	Ampicillin	156	≤ 1	> 32	20.5							77.6	1.9					20.5			
	Cefoxitin	156	4	8	0.0							25.6	17.3	40.4	16.0	0.6					
	Gentamicin	156	≤ 0.25	0.50	0.0					86.5	10.9	2.6									
	Kanamycin	156	≤ 8	≤ 8	0.0										100.0						
	Nalidixic acid	156	> 32	> 32	78.2							0.6	12.8	5.8	2.6		1.3	76.9			
	Streptomycin	156	≤ 32	> 64	20.5												79.5	0.6	19.9		
	Trimethoprim-sulfamethoxazole	156	≤ 0.12	> 4	20.5				71.2	7.7	0.6				20.5						
III	Chloramphenicol	156	4	> 32	20.5									58.3	21.2			20.5			
	Sulfisoxazole	156	64	> 256	23.1											16.0	26.9	26.9	7.1		23.1
	Tetracycline	156	≤ 4	> 32	12.8									86.5	0.6	0.6	0.6	11.5			
IV																					

Table B.1.8. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* Typhimurium isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	n	MIC Percentiles MIC 50	MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	658	≤ 1	16	1.8							72.5	5.5	0.6	7.3	12.3	0.6	1.2			
	Ceftiofur	658	1	1	1.4					0.2	8.4	88.3	1.7	0.2		1.4					
	Ceftriaxone	658	≤ 0.25	≤ 0.25	0.2					98.2	0.5				0.2	0.5	0.6	0.2			
	Ciprofloxacin	658	≤ 0.015	0.03	0.5	84.5	9.0	1.1	1.2	1.4	2.3	0.2			0.5						
II	Amikacin	658	1	2	0.0							53.8	43.2	2.9	0.2						
	Ampicillin	658	≤ 1	> 32	22.0							69.9	7.4	0.5	0.2			22.0			
	Cefoxitin	658	2	4	1.4						0.2	5.2	73.9	18.1	1.4		0.2	1.2			
	Gentamicin	658	0.50	0.50	1.7					32.2	62.2	3.6	0.2		0.2	0.3	1.4				
	Kanamycin	658	≤ 8	≤ 8	7.3										92.4	0.3			7.3		
	Nalidixic acid	658	4	4	3.5							0.2	27.2	66.0	1.4	1.8	0.3	3.2			
	Streptomycin	658	≤ 32	> 64	22.6												77.4	10.3	12.3		
	Trimethoprim-sulfamethoxazole	658	≤ 0.12	0.25	4.9				69.5	23.9	1.7		0.2		4.9						
III	Chloramphenicol	658	8	> 32	16.1								0.5	31.8	51.2	0.5	0.2	16.0			
	Sulfisoxazole	658	64	> 256	27.5											1.7	44.4	20.2	5.5	0.8	27.5
	Tetracycline	658	≤ 4	> 32	26.7									72.8	0.5	5.8	6.4	14.6			
IV																					

Table B.1.9. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* "Other Serovars" isolates from humans; *Surveillance of Human Clinical Isolates*, 2007.

	Antimicrobial	n	MIC Percentiles MIC 50	MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	1,093	≤ 1	≤ 1	1.0							90.9	3.4	0.7	2.4	1.6	0.4	0.6			
	Ceftiofur	1,093	1	1	0.7				0.1	0.5	30.3	67.2	1.3			0.7					
	Ceftriaxone	1,093	≤ 0.25	≤ 0.25	0.2					99.1	0.2					0.3	0.3	0.1	0.1		
	Ciprofloxacin	1,093	≤ 0.015	0.03	0.3	89.1	5.8	0.1	1.6	1.5	1.4	0.4			0.3						
II	Amikacin	1,093	1	2	0.0						0.9	52.7	43.0	3.1	0.3						
	Ampicillin	1,093	≤ 1	≤ 1	5.6							90.2	3.8	0.4				5.6			
	Cefoxitin	1,093	2	4	0.7						0.1	9.0	56.6	31.6	1.8	0.2	0.2	0.5			
	Gentamicin	1,093	0.50	0.50	0.5					41.4	54.8	3.2	0.1			0.2	0.4				
	Kanamycin	1,093	≤ 8	≤ 8	1.4										98.2	0.3	0.2	0.1	1.3		
	Nalidixic acid	1,093	4	4	3.3							0.3	41.1	52.7	1.8	0.8		3.3			
	Streptomycin	1,093	≤ 32	64	10.2												89.8	5.4	4.8		
	Trimethoprim-sulfamethoxazole	1,093	≤ 0.12	0.25	3.0				85.3	11.2	0.5		0.1	0.3	2.7						
III	Chloramphenicol	1,093	8	8	1.6								0.5	48.6	48.5	0.7	0.1	1.6			
	Sulfisoxazole	1,093	64	128	7.8											5.1	37.0	44.8	4.9	0.4	7.8
	Tetracycline	1,093	≤ 4	> 32	18.4									81.3	0.3	0.5	4.5	13.4			
IV																					

B.2 Antimicrobial Resistance in the Agri-Food Sector

Table B.2.1. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from cattle; *Surveillance of Animal Clinical Isolates*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	140	≤ 1	16	2.1							77.1	1.4	0.7	7.9	10.7		2.1			
I	Ceftiofur	140	1	1	2.1					0.7	35.0	60.7	1.4			2.1					
I	Ceftriaxone	140	≤ 0.25	≤ 0.25	0.0					97.9					0.7	0.7	0.7				
I	Ciprofloxacin	140	≤ 0.015	≤ 0.015	0.0	97.9	2.1														
II	Amikacin	140	1	2	0.7						2.9	57.1	32.1	6.4	0.7				0.7		
II	Ampicillin	140	≤ 1	> 32	21.4							77.1	1.4				0.7	20.7			
II	Cefoxitin	140	2	4	2.1							16.4	67.9	11.4	1.4	0.7	0.7	1.4			
II	Gentamicin	140	0.50	0.50	2.9					45.0	48.6	3.6				2.1	0.7				
II	Kanamycin	140	≤ 8	> 64	12.9										86.4	0.7			12.9		
II	Nalidixic acid	140	2	4	0.0								55.0	44.3	0.7						
II	Streptomycin	140	≤ 32	> 64	18.6												81.4	7.1	11.4		
II	Trimethoprim-sulfamethoxazole	140	≤ 0.12	0.25	2.1				74.3	23.6					2.1						
III	Chloramphenicol	140	8	> 32	17.1								7.1	39.3	36.4			17.1			
III	Sulfisoxazole	140	32	> 256	20.7											12.1	57.1	9.3		0.7	20.7
III	Tetracycline	140	≤ 4	> 32	24.3									75.7		0.7	5.0	18.6			
IV																					

Table B.2.2. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	188	4	4	0.0							10.6	38.3	48.9	2.1						
I	Ceftiofur	188	0.25	0.50	0.0				9.0	53.2	37.8										
I	Ceftriaxone	188	≤ 0.25	≤ 0.25	0.0					100.0											
I	Ciprofloxacin	188	≤ 0.015	≤ 0.015	0.0	98.9	1.1														
II	Amikacin	188	2	2	0.0						1.6	31.9	60.1	5.9	0.5						
II	Ampicillin	188	2	4	2.7							22.9	56.4	17.6		0.5		2.7			
II	Cefoxitin	188	4	8	0.0						0.5	4.3	30.9	54.3	10.1						
II	Gentamicin	188	0.50	0.50	1.1					16.0	75.0	5.3		0.5	2.1	1.1					
II	Kanamycin	188	≤ 8	≤ 8	2.1										95.2	0.5	2.1	1.1	1.1		
II	Nalidixic acid	188	2	2	0.0							14.4	81.9	3.7							
II	Streptomycin	188	≤ 32	64	11.7												88.3	10.1	1.6		
II	Trimethoprim-sulfamethoxazole	188	≤ 0.12	0.25	0.0				73.9	23.9	2.1										
III	Chloramphenicol	188	4	8	2.1								5.9	57.4	34.0	0.5		2.1			
III	Sulfisoxazole	188	≤ 16	> 256	18.1											76.6	5.3				18.1
III	Tetracycline	188	≤ 4	> 32	35.6									53.7	10.6	5.9	4.8	25.0			
IV																					

Table B.2.3. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Escherichia coli* isolates from beef, by province; *Retail Meat Surveillance*, 2007.

	Antimicrobial	Province	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	49	4	4	0.0							8.2	28.6	55.1	8.2						
		Saskatchewan	118	4	4	0.8							1.7	26.3	66.1	5.1		0.8				
		Ontario	187	4	4	0.0							4.3	31.0	58.8	5.9						
		Québec	147	4	4	0.7							4.1	30.6	60.5	4.1		0.7				
	Ceftiofur	British Columbia	49	0.25	0.50	0.0				14.3	51.0	34.7										
		Saskatchewan	118	0.25	0.50	0.0				5.1	55.1	39.0		0.8								
		Ontario	187	0.25	0.50	0.0				5.9	45.5	48.1	0.5									
I		Québec	147	0.25	0.50	0.7				5.4	59.2	34.7					0.7					
	Ceftriaxone	British Columbia	49	≤ 0.25	≤ 0.25	0.0					100.0											
		Saskatchewan	118	≤ 0.25	≤ 0.25	0.0					97.5	1.7	0.8									
		Ontario	187	≤ 0.25	≤ 0.25	0.0					100.0											
		Québec	147	≤ 0.25	≤ 0.25	0.0					99.3					0.7						
	Ciprofloxacin	British Columbia	49	≤ 0.015	≤ 0.015	0.0	98.0			2.0												
		Saskatchewan	118	≤ 0.015	≤ 0.015	0.0	100.0															
		Ontario	187	≤ 0.015	≤ 0.015	0.0	99.5				0.5											
		Québec	147	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	49	2	4	0.0							18.4	71.4	10.2							
		Saskatchewan	118	2	2	0.0							20.3	72.0	6.8	0.8						
		Ontario	187	2	2	0.0							27.3	66.3	6.4							
		Québec	147	2	2	0.0						1.4	31.3	61.2	5.4	0.7						
	Ampicillin	British Columbia	49	2	4	2.0							20.4	51.0	24.5		2.0		2.0			
		Saskatchewan	118	2	4	2.5							10.2	60.2	27.1				2.5			
		Ontario	187	2	4	2.7							17.1	58.3	20.3	1.1	0.5	0.5	2.1			
		Québec	147	2	4	3.4							13.6	63.3	19.0	0.7			3.4			
	Cefoxitin	British Columbia	49	4	4	0.0						2.0	6.1	40.8	46.9	4.1						
		Saskatchewan	118	4	4	0.8							1.7	33.1	58.5	5.9			0.8			
		Ontario	187	4	4	0.0							2.1	29.9	60.4	7.5						
		Québec	147	4	4	0.7							3.4	27.9	63.9	4.1			0.7			
	Gentamicin	British Columbia	49	0.50	0.50	0.0					10.2	83.7	6.1									
		Saskatchewan	118	0.50	0.50	0.8					13.6	78.8	5.9	0.8				0.8				
		Ontario	187	0.50	0.50	0.0					19.8	72.2	8.0									
		Québec	147	0.50	1	0.0					14.3	72.1	12.9			0.7						
II	Kanamycin	British Columbia	49	≤ 8	≤ 8	2.0										98.0				2.0		
		Saskatchewan	118	≤ 8	≤ 8	0.0										100.0						
		Ontario	187	≤ 8	≤ 8	1.1										98.4	0.5			1.1		
		Québec	147	≤ 8	≤ 8	0.7										97.3	2.0			0.7		
	Nalidixic acid	British Columbia	49	2	4	2.0						2.0	14.3	73.5	8.2				2.0			
		Saskatchewan	118	2	2	0.0							11.0	82.2	6.8							
		Ontario	187	2	4	0.5						1.6	10.7	77.0	10.2				0.5			
		Québec	147	2	2	0.0							10.2	81.0	8.8							
	Streptomycin	British Columbia	49	≤ 32	≤ 32	2.0												98.0		2.0		
		Saskatchewan	118	≤ 32	≤ 32	0.8												99.2	0.8			
		Ontario	187	≤ 32	≤ 32	3.2												96.8	1.1	2.1		
		Québec	147	≤ 32	≤ 32	6.8												93.2	2.7	4.1		
	Trimethoprim-sulfamethoxazole	British Columbia	49	≤ 0.12	0.25	4.1				79.6	16.3					4.1						
		Saskatchewan	118	≤ 0.12	0.25	0.0				83.1	15.3	1.7										
		Ontario	187	≤ 0.12	0.25	2.1				78.1	19.3	0.5				2.1						
		Québec	147	≤ 0.12	0.25	2.0				78.2	17.0	2.7				2.0						
	Chloramphenicol	British Columbia	49	4	8	0.0								8.2	57.1	34.7						
		Saskatchewan	118	4	8	0.8								5.9	49.2	43.2	0.8		0.8			
		Ontario	187	4	8	2.7								2.7	52.4	41.2	1.1		2.7			
		Québec	147	4	8	2.0								5.4	51.0	41.5		0.7	1.4			
	Sulfisoxazole	British Columbia	49	≤ 16	> 256	12.2											75.5	12.2				12.2
III		Saskatchewan	118	≤ 16	32	5.9											88.1	5.9				5.9
		Ontario	187	≤ 16	32	7.0											84.0	9.1				7.0
		Québec	147	≤ 16	32	9.5											85.7	4.8				9.5
	Tetracycline	British Columbia	49	≤ 4	> 32	10.2									85.7	4.1			10.2			
		Saskatchewan	118	≤ 4	8	7.6									88.1	4.2		1.7	5.9			
		Ontario	187	≤ 4	32	13.9									81.3	4.8	2.1	2.7	9.1			
		Québec	147	≤ 4	> 32	15.0									81.6	3.4	1.4	0.7	12.9			
IV																						

Table B.2.4. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Campylobacter* isolates from beef cattle, by *Campylobacter* species; *Abattoir Surveillance*, 2007.

	Antimicrobial	Species	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
I	Ciprofloxacin	*C. coli*	35	0.125	0.25	2.9			2.9	85.7	8.6						2.9			
	Ciprofloxacin	*C. jejuni*	30	0.064	0.125	0.0			53.3	43.3	3.3									
	Ciprofloxacin	*Campylobacter* spp.	8	0.25	0.5	0.0			25.0		62.5	12.5								
	Telithromycin	*C. coli*	35	2	4	0.0							11.4	54.3	34.3					
	Telithromycin	*C. jejuni*	30	0.5	2	0.0					3.3	53.3	33.3	10.0						
	Telithromycin	*Campylobacter* spp.	8	1	1	0.0						50.0	50.0							
II	Azithromycin	*C. coli*	35	0.125	0.25	0.0		5.7	8.6	51.4	34.3									
	Azithromycin	*C. jejuni*	30	0.064	0.064	0.0	3.3	26.7	63.3	6.7										
	Azithromycin	*Campylobacter* spp.	8	0.125	0.125	0.0		25.0	25.0	50.0										
	Clindamycin	*C. coli*	35	1	1	0.0				5.7	5.7	11.4	74.3	2.9						
	Clindamycin	*C. jejuni*	30	0.125	0.5	0.0		3.3	6.7	53.3	23.3	13.3								
	Clindamycin	*Campylobacter* spp.	8	0.25	0.5	0.0			12.5	12.5	37.5	37.5								
	Erythromycin	*C. coli*	35	2	2	0.0					5.7	8.6	2.9	80.0	2.9					
	Erythromycin	*C. jejuni*	30	0.25	1	0.0				3.3	56.7	20.0	20.0							
	Erythromycin	*Campylobacter* spp.	8	0.25	0.5	0.0				12.5	50.0	37.5								
	Gentamicin	*C. coli*	35	0.5	1	0.0						74.3	25.7							
	Gentamicin	*C. jejuni*	30	0.5	1	0.0					3.3	66.7	30.0							
	Gentamicin	*Campylobacter* spp.	8	0.25	0.5	0.0				37.5	37.5	25.0								
	Nalidixic acid	*C. coli*	35	16	16	2.9									11.4	14.3	71.4		2.9	
	Nalidixic acid	*C. jejuni*	30	≤ 4	8	0.0									76.7	23.3				
	Nalidixic acid	*Campylobacter* spp.	8	64	> 64	75.0									25.0				37.5	37.5
III	Florfenicol	*C. coli*	35	2	2	0.0						2.9	20.0	74.3	2.9					
	Florfenicol	*C. jejuni*	30	1	1	0.0						30.0	70.0							
	Florfenicol	*Campylobacter* spp.	8	1	1	0.0						12.5	87.5							
	Tetracycline	*C. coli*	35	> 64	> 64	77.1				5.7	2.9		14.3						2.9	74.3
	Tetracycline	*C. jejuni*	30	0.25	> 64	46.7				30.0	23.3						3.3	6.7	20.0	16.7
	Tetracycline	*Campylobacter* spp.	8	32	64	87.5					12.5						25.0	50.0	12.5	
IV																				

Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

Table B.2.5. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2007

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	206	≤ 1	> 32	12.1							78.2	3.9		2.4	3.4	1.0	11.2			
	Ceftiofur	206	1	> 8	12.1				0.5		28.6	57.3	1.5			12.1					
	Ceftriaxone	206	≤ 0.25	8	0.0					87.9					5.8	4.4	1.9				
	Ciprofloxacin	206	≤ 0.015	0.03	0.0	83.0	17.0														
II	Amikacin	206	1	2	0.0						12.6	51.0	33.5	2.9							
	Ampicillin	206	≤ 1	> 32	18.0							78.2	3.9					18.0			
	Cefoxitin	206	2	32	10.7						0.5	18.9	53.4	12.1	2.9	1.5	7.3	3.4			
	Gentamicin	206	≤ 0.25	0.50	0.0					59.2	36.4	4.4									
	Kanamycin	206	≤ 8	≤ 8	1.5										98.5				1.5		
	Nalidixic acid	206	4	4	0.0							3.4	40.8	53.4	2.4						
	Streptomycin	206	≤ 32	> 64	37.4												62.6	20.9	16.5		
	Trimethoprim-sulfamethoxazole	206	≤ 0.12	0.25	0.0				85.9	14.1											
III	Chloramphenicol	206	4	8	1.5								5.3	46.6	44.7	1.9		1.5			
	Sulfisoxazole	206	32	64	3.4											20.4	58.7	17.0	0.5		3.4
	Tetracycline	206	≤ 4	> 32	44.2									55.3	0.5		2.9	41.3			
IV																					

Table B.2.6. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* isolates from chicken, by province; *Retail Meat Surveillance*, 2007.

	Antimicrobial	Province	n	Percentile MIC 50	Percentile MIC 90	% R	≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	Amoxicillin-clavulanic acid	British Columbia	18	≤ 1	> 32	33.3							61.1			5.6		5.6	27.8			
		Ontario	172	≤ 1	32	11.0							82.0	1.7		2.9	2.3	3.5	7.6			
		Québec	113	≤ 1	8	8.0							82.3	1.8		6.2	1.8		8.0			
		Saskatchewan	43	≤ 1	8	2.3							76.7		2.3	14.0	4.7		2.3			
	Ceftiofur	British Columbia	18	1	> 8	33.3						16.7	50.0				33.3					
		Ontario	172	1	> 8	11.0					1.2	35.5	51.7	0.6		0.6	10.5					
		Québec	113	1	1	8.8					0.9	37.2	52.2	0.9			8.8					
I		Saskatchewan	43	1	1	2.3						30.2	67.4				2.3					
	Ceftriaxone	British Columbia	18	≤ 0.25	16	0.0					66.7					16.7	11.1	5.6				
		Ontario	172	≤ 0.25	8	0.0					89.0				0.6	3.5	5.2	1.7				
		Québec	113	≤ 0.25	≤ 0.25	0.0					91.2					2.7	2.7	3.5				
		Saskatchewan	43	≤ 0.25	≤ 0.25	0.0					97.7							2.3				
	Ciprofloxacin	British Columbia	18	≤ 0.015	0.03	0.0	83.3	16.7														
		Ontario	172	≤ 0.015	0.03	0.0	78.5	21.5														
		Québec	113	≤ 0.015	0.03	0.0	85.0	15.0														
		Saskatchewan	43	≤ 0.015	0.03	0.0	86.0	14.0														
	Amikacin	British Columbia	18	1	2	0.0						5.6	72.2	22.2								
		Ontario	172	1	2	0.0						12.2	72.1	13.4	1.7	0.6						
		Québec	113	1	2	0.0						12.4	63.7	22.1	0.9	0.9						
		Saskatchewan	43	1	2	0.0						4.7	67.4	27.9								
	Ampicillin	British Columbia	18	2	> 32	38.9							50.0	11.1					38.9			
		Ontario	172	≤ 1	> 32	16.3							80.8	2.9					16.3			
		Québec	113	≤ 1	> 32	15.9							80.5	3.5					15.9			
		Saskatchewan	43	≤ 1	> 32	23.3							76.7						23.3			
	Cefoxitin	British Columbia	18	4	32	33.3								50.0	11.1	5.6		27.8	5.6			
		Ontario	172	2	32	11.0							22.7	54.1	11.6	0.6		7.6	3.5			
		Québec	113	2	4	7.1							19.5	52.2	18.6	1.8	0.9	2.7	4.4			
		Saskatchewan	43	2	4	2.3							16.3	53.5	25.6	2.3			2.3			
II	Gentamicin	British Columbia	18	≤ 0.25	0.50	0.0					66.7	33.3										
		Ontario	172	≤ 0.25	0.50	1.7					77.9	19.2	0.6	0.6			0.6	1.2				
		Québec	113	≤ 0.25	0.50	2.7					69.0	27.4		0.9			0.9	1.8				
		Saskatchewan	43	≤ 0.25	0.50	0.0					60.5	39.5										
	Kanamycin	British Columbia	18	≤ 8	≤ 8	0.0										100.0						
		Ontario	172	≤ 8	≤ 8	1.2										98.3	0.6			1.2		
		Québec	113	≤ 8	≤ 8	0.0										100.0						
		Saskatchewan	43	≤ 8	≤ 8	2.3										97.7				2.3		
	Nalidixic acid	British Columbia	18	4	4	0.0								33.3	61.1	5.6						
		Ontario	172	4	4	0.0							2.3	33.1	58.7	5.8						
		Québec	113	4	4	0.0							1.8	32.7	64.6	0.9						
		Saskatchewan	43	4	4	0.0								34.9	65.1							
	Streptomycin	British Columbia	18	≤ 32	64	11.1												88.9	5.6	5.6		
		Ontario	172	≤ 32	> 64	30.8												69.2	18.6	12.2		
		Québec	113	≤ 32	> 64	37.2												62.8	24.8	12.4		
		Saskatchewan	43	≤ 32	> 64	37.2												62.8	16.3	20.9		
II	Trimethoprim-sulfamethoxazole	British Columbia	18	≤ 0.12	0.25	0.0				83.3	16.7											
		Ontario	172	≤ 0.12	0.25	0.6				87.8	11.6					0.6						
		Québec	113	≤ 0.12	0.25	0.0				85.0	12.4	0.9		1.8								
		Saskatchewan	43	≤ 0.12	0.25	2.3				88.4	9.3					2.3						
	Chloramphenicol	British Columbia	18	4	8	0.0								5.6	50.0	44.4						
		Ontario	172	4	8	0.0								2.9	53.5	43.0	0.6					
		Québec	113	8	8	0.0								5.3	41.6	53.1						
		Saskatchewan	43	8	8	2.3								4.7	41.9	51.2			2.3			
	Sulfisoxazole	British Columbia	18	32	64	0.0											38.9	44.4	16.7			
III		Ontario	172	32	64	3.5											32.0	56.4	7.6	0.6		3.5
		Québec	113	32	64	8.8											27.4	50.4	13.3			8.8
		Saskatchewan	43	32	64	7.0											20.9	67.4	4.7			7.0
	Tetracycline	British Columbia	18	≤ 4	> 32	16.7									77.8	5.6		5.6	11.1			
		Ontario	172	≤ 4	> 32	34.3									64.5	1.2		2.3	32.0			
		Québec	113	≤ 4	> 32	37.2									62.8			2.7	34.5			
		Saskatchewan	43	≤ 4	> 32	34.9									65.1			4.7	30.2			
IV																						

Table B.2.7. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from chickens; *Surveillance of Animal Clinical Isolates*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	105	≤ 1	> 32	13.3							82.9	1.0			2.9	2.9	10.5			
	Ceftiofur	105	1	> 8	13.3						13.3	73.3				13.3					
	Ceftriaxone	105	≤ 0.25	8	1.0					86.7					4.8	4.8	2.9	1.0			
	Ciprofloxacin	105	≤ 0.015	0.03	0.0	81.0	19.0														
II	Amikacin	105	1	2	0.0						5.7	79.0	11.4	3.8							
	Ampicillin	105	≤ 1	> 32	16.2							80.0	3.8					16.2			
	Cefoxitin	105	2	32	13.3							10.5	67.6	8.6			7.6	5.7			
	Gentamicin	105	≤ 0.25	0.50	2.9					66.7	26.7	3.8				1.0	1.9				
	Kanamycin	105	≤ 8	≤ 8	2.9										96.2		1.0		2.9		
	Nalidixic acid	105	4	4	0.0								28.6	71.4							
	Streptomycin	105	≤ 32	≤ 32	7.6												92.4	4.8	2.9		
	Trimethoprim-sulfamethoxazole	105	≤ 0.12	≤ 0.12	0.0				91.4	8.6											
III	Chloramphenicol	105	8	8	1.0									36.2	62.9			1.0			
	Sulfisoxazole	105	32	64	2.9											14.3	70.5	12.4			2.9
	Tetracycline	105	≤ 4	> 32	13.3									86.7			1.0	12.4			
IV																					

Table B.2.8. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	180	4	32	26.7							3.3	27.2	30.6	11.1	1.1	20.6	6.1			
	Ceftiofur	180	0.50	> 8	26.1				3.3	35.0	32.2	1.7	1.7		15.0	11.1					
	Ceftriaxone	180	≤ 0.25	16	0.0					71.7	0.6	1.7		1.7	10.0	12.8	1.7				
	Ciprofloxacin	180	≤ 0.015	≤ 0.015	0.0	97.2	0.6	0.6	1.1	0.6											
II	Amikacin	180	2	4	0.0						0.6	25.0	62.8	10.6	1.1						
	Ampicillin	180	4	> 32	38.9							12.2	35.6	12.8	0.6		0.6	38.3			
	Cefoxitin	180	4	> 32	27.2						0.6	0.6	16.7	41.1	13.3	0.6	5.0	22.2			
	Gentamicin	180	0.50	16	11.1					12.2	61.7	11.1		2.2	1.7	5.6	5.6				
	Kanamycin	180	≤ 8	> 64	10.6										86.7	1.7	1.1	0.6	10.0		
	Nalidixic acid	180	2	2	2.2							23.3	68.3	6.1			1.1	1.1			
	Streptomycin	180	≤ 32	> 64	40.0												60.0	17.8	22.2		
	Trimethoprim-sulfamethoxazole	180	≤ 0.12	0.50	4.4				55.0	34.4	5.6	0.6			4.4						
III	Chloramphenicol	180	4	8	4.4								5.6	48.9	39.4	1.7		4.4			
	Sulfisoxazole	180	≤ 16	> 256	40.0											53.3	6.7				40.0
	Tetracycline	180	> 32	> 32	57.2									42.8			5.0	52.2			
IV																					

Table B.2.9. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Escherichia coli* isolates from chicken, by province; *Retail Meat Surveillance*, 2007.

	Antimicrobial	Province	n	Percentile		% 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	> 256
	Amoxicillin-clavulanic acid	British Columbia	42	8	32	33.3							2.4	11.9	33.3	19.0		31.0	2.4			
		Saskatchewan	75	4	32	17.3							9.3	26.7	33.3	13.3		17.3				
		Ontario	157	4	32	26.8							4.5	26.8	29.3	10.8	1.9	22.3	4.5			
		Québec	128	4	32	18.0							5.5	34.4	24.2	15.6	2.3	14.8	3.1			
	Ceftiofur	British Columbia	42	0.50	8	28.6				2.4	23.8	26.2	7.1	7.1	4.8	19.0	9.5					
		Saskatchewan	75	0.50	8	13.3				6.7	41.3	33.3	2.7		2.7	8.0	5.3					
		Ontario	157	0.50	8	22.3				1.3	38.9	32.5	1.3		3.8	15.9	6.4					
I		Québec	128	0.50	8	13.3				4.7	38.3	37.5	1.6	0.8	3.9	10.2	3.1					
	Ceftriaxone	British Columbia	42	≤ 0.25	8	0.0					54.8	2.4	9.5		4.8	21.4	7.1					
		Saskatchewan	75	≤ 0.25	8	0.0					81.3	1.3	1.3		4.0	6.7	5.3					
		Ontario	157	≤ 0.25	8	0.6					72.6		1.3	0.6	4.5	14.6	5.1	0.6	0.6			
		Québec	128	≤ 0.25	8	0.0					82.0		0.8	0.8	4.7	5.5	5.5	0.8				
	Ciprofloxacin	British Columbia	42	≤ 0.015	≤ 0.015	0.0	95.2			2.4	2.4											
		Saskatchewan	75	≤ 0.015	≤ 0.015	0.0	94.7			2.7	2.7											
		Ontario	157	≤ 0.015	≤ 0.015	0.0	96.8			1.3	1.9											
		Québec	128	≤ 0.015	≤ 0.015	0.0	94.5	2.3		2.3	0.8											
	Amikacin	British Columbia	42	2	4	0.0							26.2	57.1	11.9	4.8						
		Saskatchewan	75	2	2	0.0							25.3	69.3	4.0	1.3						
		Ontario	157	2	4	0.0						1.3	17.2	65.0	14.0	1.9	0.6					
		Québec	128	2	2	0.0						2.3	27.3	60.9	8.6	0.8						
	Ampicillin	British Columbia	42	> 32	> 32	59.5							7.1	23.8	9.5				59.5			
		Saskatchewan	75	2	> 32	34.7							18.7	33.3	12.0		1.3		34.7			
		Ontario	157	4	> 32	38.9							14.0	31.8	14.6		0.6		38.9			
		Québec	128	2	> 32	34.4							18.0	38.3	9.4			0.8	33.6			
	Cefoxitin	British Columbia	42	8	> 32	33.3								21.4	28.6	14.3	2.4	11.9	21.4			
		Saskatchewan	75	4	32	16.0							1.3	30.7	42.7	8.0	1.3	8.0	8.0			
		Ontario	157	4	> 32	25.5								16.6	49.7	6.4	1.9	3.8	21.7			
		Québec	128	4	> 32	17.2							0.8	21.9	53.9	4.7	1.6	6.3	10.9			
II	Gentamicin	British Columbia	42	0.50	1	0.0					4.8	73.8	14.3	2.4	2.4	2.4						
		Saskatchewan	75	0.50	16	10.7					16.0	61.3	8.0		2.7	1.3	4.0	6.7				
		Ontario	157	0.50	16	13.4					7.0	63.1	15.3	0.6		0.6	3.8	9.6				
		Québec	128	0.50	> 16	24.2					18.0	49.2	7.8			0.8	10.9	13.3				
	Kanamycin	British Columbia	42	≤ 8	≤ 8	2.4										97.6				2.4		
		Saskatchewan	75	≤ 8	> 64	10.7										85.3	4.0			10.7		
		Ontario	157	≤ 8	> 64	10.2										86.6	3.2			10.2		
		Québec	128	≤ 8	16	7.8										87.5	4.7		0.8	7.0		
	Nalidixic acid	British Columbia	42	2	4	4.8							4.8	78.6	9.5	2.4			4.8			
		Saskatchewan	75	2	2	5.3						1.3	22.7	69.3	1.3			2.7	2.7			
		Ontario	157	2	4	3.2							10.8	77.7	7.6	0.6			3.2			
		Québec	128	2	2	3.1							18.8	72.7	5.5			0.8	2.3			
	Streptomycin	British Columbia	42	≤ 32	64	21.4												78.6	11.9	9.5		
		Saskatchewan	75	≤ 32	> 64	32.0												68.0	14.7	17.3		
		Ontario	157	≤ 32	> 64	30.6												69.4	12.7	17.8		
		Québec	128	≤ 32	> 64	36.7												63.3	18.0	18.8		
II	Trimethoprim-sulfamethoxazole	British Columbia	42	≤ 0.12	> 4	16.7				59.5	19.0	4.8				16.7						
		Saskatchewan	75	≤ 0.12	0.25	4.0				62.7	30.7	2.7				4.0						
		Ontario	157	≤ 0.12	0.50	3.8				58.0	31.2	6.4		0.6		3.8						
		Québec	128	≤ 0.12	> 4	11.7				53.1	28.1	5.5	1.6			11.7						
	Chloramphenicol	British Columbia	42	8	8	2.4								2.4	47.6	47.6			2.4			
		Saskatchewan	75	4	8	1.3								1.3	68.0	29.3			1.3			
		Ontario	157	4	8	3.2								3.8	54.8	38.2			3.2			
		Québec	128	4	8	2.3								7.8	57.8	31.3	0.8		2.3			
	Sulfisoxazole	British Columbia	42	32	> 256	26.2											47.6	23.8	2.4			26.2
III		Saskatchewan	75	≤ 16	> 256	29.3											62.7	8.0				29.3
		Ontario	157	≤ 16	> 256	28.0											61.1	10.8				28.0
		Québec	128	32	> 256	46.9											46.1	7.0				46.9
	Tetracycline	British Columbia	42	≤ 4	> 32	45.2									54.8				45.2			
		Saskatchewan	75	≤ 4	> 32	44.0									56.0			4.0	40.0			
		Ontario	157	≤ 4	> 32	48.4									50.3	1.3	0.6	1.9	45.9			
		Québec	128	≤ 4	> 32	48.4									50.8	0.8	0.8	3.1	44.5			
IV																						

Table B.2.10. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter species and province; Retail Meat Surveillance*, 2007.

	Antimicrobial	Species	Province	n	Percentile CMI 50	Percentile CMI 90	% R	Distribution (%) of MICs ≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
	Ciprofloxacin	*C. coli*	British Columbia	2	0.125	0.125	0.0			50.0	50.0										
	Ciprofloxacin	*C. coli*	Saskatchewan	10	0.125	16	20.0			40.0	20.0	20.0					10.0	10.0			
	Ciprofloxacin	*C. coli*	Ontario	17	0.125	0.25	5.9			23.5	58.8	11.8					5.9				
	Ciprofloxacin	*C. coli*	Québec	14	0.25	8	42.9				14.3	42.9					35.7		7.1		
	Ciprofloxacin	*C. jejuni*	British Columbia	26	0.125	0.125	3.8			46.2	50.0						3.8				
	Ciprofloxacin	*C. jejuni*	Saskatchewan	39	0.125	0.125	2.6			41.0	53.8	2.6					2.6				
	Ciprofloxacin	*C. jejuni*	Ontario	97	0.064	0.25	0.0			56.7	29.9	13.4									
	Ciprofloxacin	*C. jejuni*	Québec	44	0.064	0.25	4.5			63.6	20.5	11.4					4.5				
	Ciprofloxacin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Ciprofloxacin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Ciprofloxacin	*Campylobacter* spp.	Ontario	3	0.064	0.125	0.0			66.7	33.3										
	Ciprofloxacin	*Campylobacter* spp.	Québec	1	0.064	0.064	0.0			100.0											
I	Telithromycin	*C. coli*	British Columbia	2	0.5	0.5	0.0					50.0	50.0								
	Telithromycin	*C. coli*	Saskatchewan	10	0.5	16	10.0					10.0	50.0	20.0	10.0			10.0			
	Telithromycin	*C. coli*	Ontario	17	1	2	0.0					5.9	29.4	52.9	11.8						
	Telithromycin	*C. coli*	Québec	14	1	16	21.4					7.1	28.6	21.4		7.1	14.3	21.4			
	Telithromycin	*C. jejuni*	British Columbia	26	0.5	1	0.0					15.4	53.8	26.9	3.8						
	Telithromycin	*C. jejuni*	Saskatchewan	39	0.5	1	0.0					10.3	51.3	33.3	5.1						
	Telithromycin	*C. jejuni*	Ontario	97	0.5	2	1.0					14.4	51.5	17.5	14.4		1.0	1.0			
	Telithromycin	*C. jejuni*	Québec	44	0.5	2	0.0					18.2	52.3	15.9	9.1	2.3	2.3				
	Telithromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Telithromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Telithromycin	*Campylobacter* spp.	Ontario	3	0.5	0.5	0.0						100.0								
	Telithromycin	*Campylobacter* spp.	Québec	1	0.25	0.25	0.0					100.0									
	Azithromycin	*C. coli*	British Columbia	2	0.032	0.032	0.0		100.0												
	Azithromycin	*C. coli*	Saskatchewan	10	0.064	> 64	10.0		50.0	40.0											10.0
	Azithromycin	*C. coli*	Ontario	17	0.064	0.125	0.0	5.9	23.5	52.9	17.6										
	Azithromycin	*C. coli*	Québec	14	0.064	> 64	28.6	28.6	21.4	14.3	7.1										28.6
	Azithromycin	*C. jejuni*	British Columbia	26	0.064	0.064	0.0	3.8	38.5	57.7											
	Azithromycin	*C. jejuni*	Saskatchewan	39	0.064	0.064	0.0		38.5	56.4	5.1										
	Azithromycin	*C. jejuni*	Ontario	97	0.064	0.125	2.1	5.2	33.0	45.4	14.4										2.1
	Azithromycin	*C. jejuni*	Québec	44	0.064	0.125	4.5	4.5	45.5	34.1	11.4										4.5
	Azithromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Azithromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Azithromycin	*Campylobacter* spp.	Ontario	3	0.032	0.032	0.0		100.0												
	Azithromycin	*Campylobacter* spp.	Québec	1	0.032	0.032	0.0		100.0												
	Clindamycin	*C. coli*	British Columbia	2	0.125	0.125	0.0				100.0										
	Clindamycin	*C. coli*	Saskatchewan	10	0.125	16	10.0			10.0	50.0	20.0	10.0					10.0			
	Clindamycin	*C. coli*	Ontario	17	0.125	1	0.0			17.6	41.2	23.5		11.8		5.9					
	Clindamycin	*C. coli*	Québec	14	0.125	4	7.1			28.6	28.6	7.1	7.1			21.4	7.1				
	Clindamycin	#	British Columbia	26	0.125	0.25	0.0			7.7	46.2	38.5	3.8	3.8							
II	Clindamycin	*C. jejuni*	Saskatchewan	39	0.125	0.25	0.0			10.3	56.4	30.8	2.6								
	Clindamycin	*C. jejuni*	Ontario	97	0.125	0.25	1.0		1.0	9.3	58.8	24.7	4.1			1.0	1.0				
	Clindamycin	*C. jejuni*	Québec	44	0.125	0.25	2.3			11.4	61.4	18.2	4.5			2.3	2.3				
	Clindamycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Clindamycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Clindamycin	*Campylobacter* spp.	Ontario	3	0.125	0.125	0.0			33.3	66.7										
	Clindamycin	*Campylobacter* spp.	Québec	1	0.125	0.125	0.0				100.0										
	Erythromycin	*C. coli*	British Columbia	2	0.25	0.25	0.0					100.0									
	Erythromycin	*C. coli*	Saskatchewan	10	0.25	> 64	10.0				20.0	40.0	20.0	10.0							10.0
	Erythromycin	*C. coli*	Ontario	17	0.5	1	0.0					35.3	35.3	23.5	5.9						
	Erythromycin	*C. coli*	Québec	14	0.5	> 64	28.6				7.1	28.6	21.4		14.3						28.6
	Erythromycin	*C. jejuni*	British Columbia	26	0.25	0.5	0.0				11.5	65.4	23.1								
	Erythromycin	*C. jejuni*	Saskatchewan	39	0.25	0.5	0.0				5.1	56.4	33.3	5.1							
	Erythromycin	*C. jejuni*	Ontario	97	0.25	1	2.1				9.3	48.5	27.8	10.3	2.1						2.1
	Erythromycin	*C. jejuni*	Québec	44	0.25	1	4.5				13.6	47.7	22.7	9.1	2.3						4.5
	Erythromycin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Erythromycin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Erythromycin	*Campylobacter* spp.	Ontario	3	0.25	0.25	0.0					100.0									
	Erythromycin	*Campylobacter* spp.	Québec	1	0.125	0.125	0.0				100.0										

Table B.2.10 (continued). Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter species and province; Retail Meat Surveillance*, 2007.

	Antimicrobial	Species	Province	n	Percentile		% R	Distribution (%) of MICs													
					CMI 50	CMI 90		≤ 0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	> 64
	Gentamicin	*C. coli*	British Columbia	2	0.5	0.5	0.0						100.0								
	Gentamicin	*C. coli*	Saskatchewan	10	0.5	1	0.0				10.0		70.0	20.0							
	Gentamicin	*C. coli*	Ontario	17	0.5	1	0.0						70.6	23.5	5.9						
	Gentamicin	*C. coli*	Québec	14	0.5	0.5	0.0					21.4	71.4	7.1							
	Gentamicin	*C. jejuni*	British Columbia	26	0.5	0.5	0.0					3.8	92.3	3.8							
	Gentamicin	*C. jejuni*	Saskatchewan	39	0.5	1	0.0						76.9	23.1							
	Gentamicin	*C. jejuni*	Ontario	97	0.5	1	0.0					2.1	77.3	20.6							
	Gentamicin	*C. jejuni*	Québec	44	0.5	0.5	0.0					4.5	93.2	2.3							
	Gentamicin	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Gentamicin	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Gentamicin	*Campylobacter* spp.	Ontario	3	0.5	0.5	0.0						100.0								
II	Gentamicin	*Campylobacter* spp.	Québec	1	0.5	0.5	0.0						100.0								
	Nalidixic acid	*C. coli*	British Columbia	2	≤ 4	≤ 4	0.0									100.0					
	Nalidixic acid	*C. coli*	Saskatchewan	10	8	> 64	20.0									50.0	30.0				20.0
	Nalidixic acid	*C. coli*	Ontario	17	≤ 4	16	5.9									58.8	29.4	5.9			5.9
	Nalidixic acid	*C. coli*	Québec	14	8	> 64	42.9									14.3	42.9				42.9
	Nalidixic acid	*C. jejuni*	British Columbia	26	≤ 4	8	3.8									88.5	7.7			3.8	
	Nalidixic acid	*C. jejuni*	Saskatchewan	39	≤ 4	8	2.6									82.1	15.4				2.6
	Nalidixic acid	*C. jejuni*	Ontario	97	≤ 4	8	0.0									80.4	19.6				
	Nalidixic acid	*C. jejuni*	Québec	44	≤ 4	8	4.5									81.8	13.6				4.5
	Nalidixic acid	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Nalidixic acid	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Nalidixic acid	*Campylobacter* spp.	Ontario	3	≤ 4	8	0.0									66.7	33.3				
	Nalidixic acid	*Campylobacter* spp.	Québec	1	≤ 4	≤ 4	0.0									100.0					
	Florfenicol	*C. coli*	British Columbia	2	1	1	0.0						50.0	50.0							
	Florfenicol	*C. coli*	Saskatchewan	10	1	1	0.0						40.0	60.0							
	Florfenicol	*C. coli*	Ontario	17	1	1	0.0						23.5	70.6	5.9						
	Florfenicol	*C. coli*	Québec	14	1	2	0.0							78.6	21.4						
	Florfenicol	*C. jejuni*	British Columbia	26	1	1	0.0						30.8	69.2							
	Florfenicol	*C. jejuni*	Saskatchewan	39	1	1	0.0					2.6	20.5	71.8	5.1						
	Florfenicol	*C. jejuni*	Ontario	97	1	1	0.0						27.8	64.9	7.2						
	Florfenicol	*C. jejuni*	Québec	44	1	1	0.0						25.0	65.9	9.1						
	Florfenicol	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Florfenicol	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Florfenicol	*Campylobacter* spp.	Ontario	3	1	1	0.0							100.0							
III	Florfenicol	*Campylobacter* spp.	Québec	1	0.5	0.5	0.0						100.0								
	Tetracycline	*C. coli*	British Columbia	2	0.125	0.125	0.0				100.0										
	Tetracycline	*C. coli*	Saskatchewan	10	32	> 64	70.0				20.0	10.0							40.0	10.0	20.0
	Tetracycline	*C. coli*	Ontario	17	2	> 64	47.1				17.6	11.8	5.9	11.8	5.9					23.5	23.5
	Tetracycline	*C. coli*	Québec	14	0.5	> 64	21.4				28.6	7.1	28.6	14.3						7.1	14.3
	Tetracycline	*C. jejuni*	British Columbia	26	0.25	> 64	42.3				30.8	26.9							3.8	15.4	23.1
	Tetracycline	*C. jejuni*	Saskatchewan	39	0.25	> 64	30.8				33.3	28.2	5.1		2.6				7.7	12.8	10.3
	Tetracycline	*C. jejuni*	Ontario	97	64	> 64	57.7			1.0	15.5	12.4	5.2	6.2	1.0		1.0		1.0	36.1	20.6
	Tetracycline	*C. jejuni*	Québec	44	64	> 64	63.6				18.2	11.4	4.5				2.3		4.5	36.4	22.7
	Tetracycline	*Campylobacter* spp.	British Columbia	0	0	0	0.0														
	Tetracycline	*Campylobacter* spp.	Saskatchewan	0	0	0	0.0														
	Tetracycline	*Campylobacter* spp.	Ontario	3	64	> 64	100.0													66.7	33.3
	Tetracycline	*Campylobacter* spp.	Québec	1	64	64	100.0													100.0	
IV																					

Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

Table B.2.11. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus species and province; Retail Meat Surveillance*, 2007.

Antimicrobial	Species	Province	n	Percentile		% 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	1,024	2,048	> 2,048
Ciprofloxacin	*E. faecalis*	British Columbia	38	1	2	0.0						2.6	60.5	36.8											
		Saskatchewan	68	1	2	0.0						2.9	67.6	29.4											
		Ontario	154	1	2	0.6						1.9	70.8	26.6	0.6										
		Québec	128	1	2	0.0					0.8	1.6	78.1	19.5											
	E. faecium	British Columbia	2	2	2	0.0						50.0		50.0											
		Saskatchewan	3	2	4	33.3							33.3	33.3	33.3										
		Ontario	4	1	2	0.0							75.0	25.0											
		Québec	5	4	4	60.0							20.0	20.0	60.0										
	Enterococcus spp.	British Columbia	2	0.5	0.5	0.0					50.0	50.0													
		Saskatchewan	5	1	4	20.0					40.0		20.0	20.0	20.0										
		Ontario	3	0.5	2	0.0					33.3	33.3		33.3											
		Québec	8	1	2	0.0				12.5	12.5		62.5	12.5											
Daptomycin	*E. faecalis*	British Columbia	38	≤ 0.5	1	0.0						55.3	42.1	2.6											
		Saskatchewan	68	1	1	0.0						48.5	51.5												
		Ontario	154	1	1	0.0						44.8	54.5	0.6											
		Québec	128	1	1	0.0						40.6	54.7	4.7											
	E. faecium	British Columbia	2	2	2	0.0								100.0											
		Saskatchewan	3	1	2	0.0						33.3	33.3	33.3											
		Ontario	4	2	4	0.0							25.0	50.0	25.0										
		Québec	5	2	4	0.0								60.0	40.0										
	Enterococcus spp.	British Columbia	2	2	2	0.0						50.0		50.0											
		Saskatchewan	5	≤ 0.5	1	0.0						80.0	20.0												
		Ontario	3	≤ 0.5	≤ 0.5	0.0						100.0													
		Québec	8	≤ 0.5	2	0.0						62.5	25.0	12.5											
Linezolid	*E. faecalis*	British Columbia	38	2	2	0.0							15.8	84.2											
		Saskatchewan	68	2	2	0.0							8.8	91.2											
		Ontario	154	2	2	0.0							14.9	84.4	0.6										
		Québec	128	2	2	0.0							13.3	86.7											
	E. faecium	British Columbia	2	1	1	0.0							100.0												
		Saskatchewan	3	1	2	0.0							66.7	33.3											
		Ontario	4	2	2	0.0								100.0											
		Québec	5	2	2	0.0							20.0	80.0											
	Enterococcus spp.	British Columbia	2	2	2	0.0							50.0	50.0											
		Saskatchewan	5	1	2	0.0							60.0	40.0											
		Ontario	3	2	2	0.0							33.3	66.7											
		Québec	8	2	2	0.0							37.5	62.5											
Quinupristin-dalfopristin[a]	*E. faecium*	British Columbia	2	4	4	50.0							50.0		50.0										
		Saskatchewan	3	8	32	66.7								33.3		33.3		33.3							
		Ontario	4	8	16	100.0									25.0	50.0	25.0								
		Québec	5	16	16	100.0									20.0	20.0	60.0								
	Enterococcus spp.	British Columbia	2	8	8	50.0								50.0		50.0									
		Saskatchewan	5	2	16	40.0							20.0	40.0		20.0	20.0								
		Ontario	3	4	8	66.7								33.3	33.3	33.3									
		Québec	8	8	16	62.5								37.5	12.5	37.5	12.5								
Tigecycline	*E. faecalis*	British Columbia	38	0.25	0.25	0.0				34.2	65.8														
		Saskatchewan	68	0.25	0.25	0.0			1.5	47.1	51.5														
		Ontario	154	0.25	0.25	0.0				41.6	58.4														
		Québec	128	0.25	0.25	0.0				48.4	51.6														
	E. faecium	British Columbia	2	0.12	0.12	0.0				100.0															
		Saskatchewan	3	0.12	0.12	0.0				100.0															
		Ontario	4	0.12	0.12	0.0			25.0	75.0															
		Québec	5	0.12	0.12	0.0				100.0															
	Enterococcus spp.	British Columbia	2	0.12	0.12	0.0				100.0															
		Saskatchewan	5	0.12	0.12	0.0		20.0		80.0															
		Ontario	3	0.12	0.12	0.0				100.0															
		Québec	8	0.12	0.25	0.0				75.0	25.0														
Vancomycin	*E. faecalis*	British Columbia	38	1	2	0.0							76.3	23.7											
		Saskatchewan	68	1	2	0.0							70.6	29.4											
		Ontario	154	1	2	0.0							72.1	27.9											
		Québec	128	1	2	0.0							71.1	28.9											
	E. faecium	British Columbia	2	2	2	0.0						50.0		50.0											
		Saskatchewan	3	≤ 0.5	1	0.0						66.7	33.3												
		Ontario	4	≤ 0.5	1	0.0						75.0	25.0												
		Québec	5	≤ 0.5	1	0.0						60.0	40.0												
	Enterococcus spp.	British Columbia	2	1	1	0.0						50.0	50.0												
		Saskatchewan	5	≤ 0.5	2	0.0						60.0	20.0	20.0											
		Ontario	3	≤ 0.5	2	0.0						66.7		33.3											
		Québec	8	1	8	0.0						25.0	50.0	12.5		12.5									
Erythromycin	*E. faecalis*	British Columbia	38	1	> 8	47.4						39.5	13.2				47.4								
		Saskatchewan	68	2	> 8	44.1						38.2	11.8	5.9			44.1								
		Ontario	154	1	> 8	39.6						43.5	11.7	5.2			39.6								
		Québec	128	2	> 8	47.7						35.2	12.5	4.7		0.8	46.9								
	E. faecium	British Columbia	2	2	2	0.0						50.0		50.0											
		Saskatchewan	3	> 8	> 8	100.0											100.0								
		Ontario	4	8	> 8	50.0						25.0		25.0		25.0	25.0								
		Québec	5	≤ 0.5	> 8	20.0						80.0					20.0								
	Enterococcus spp.	British Columbia	2	≤ 0.5	≤ 0.5	0.0						100.0													
		Saskatchewan	5	1	> 8	40.0						40.0	20.0				40.0								
		Ontario	3	1	> 8	33.3						33.3	33.3				33.3								
		Québec	8	2	> 8	37.5						50.0		12.5			37.5								
Gentamicin	*E. faecalis*	British Columbia	38	≤ 128	≤ 128	5.3														94.7		2.6	2.6		
		Saskatchewan	68	≤ 128	≤ 128	4.4														95.6		1.5	1.5	1.5	
		Ontario	154	≤ 128	≤ 128	8.4														90.9	0.6	2.6	0.6	5.2	
		Québec	128	≤ 128	512	10.9														87.5	1.6	3.9	3.9	3.1	
	E. faecium	British Columbia	2	≤ 128	≤ 128	0.0														100.0					
		Saskatchewan	3	≤ 128	≤ 128	0.0														100.0					
		Ontario	4	≤ 128	≤ 128	0.0														100.0					
		Québec	5	≤ 128	≤ 128	0.0														100.0					
	Enterococcus spp.	British Columbia	2	≤ 128	≤ 128	0.0														100.0					
		Saskatchewan	5	≤ 128	≤ 128	0.0														100.0					
		Ontario	3	≤ 128	≤ 128	0.0														100.0					
		Québec	8	≤ 128	> 1024	25.0														75.0			12.5	12.5	
Kanamycin	*E. faecalis*	British Columbia	38	≤ 128	> 1024	15.8														84.2				15.8	
		Saskatchewan	68	≤ 128	> 1024	20.6														79.4			1.5	19.1	
		Ontario	154	≤ 128	> 1024	13.6														85.1	1.3			13.6	
		Québec	128	≤ 128	> 1024	24.2														75.8				24.2	
	E. faecium	British Columbia	2	≤ 128	≤ 128	0.0														100.0					
		Saskatchewan	3	≤ 128	≤ 128	0.0														100.0					
		Ontario	4	256	512	0.0														50.0	25.0	25.0			
		Québec	5	256	512	0.0														20.0	40.0	40.0			
	Enterococcus spp.	British Columbia	2	≤ 128	≤ 128	0.0														100.0					
		Saskatchewan	5	≤ 128	≤ 128	0.0														100.0					
		Ontario	3	≤ 128	≤ 128	0.0														100.0					
		Québec	8	≤ 128	> 1024	25.0														75.0				25.0	

[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Table B.2.11 (continued). Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Enterococcus* isolates from chicken, by *Enterococcus species and province; Retail Meat Surveillance*, 2007.

	Antimicrobial	Species	Province	n	Percentile MIC 50	Percentile MIC 90	% R	Distribution (%) of MICs ≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1,024	2,048	> 2,048
	Lincomycin[a]	*E. faecium*	British Columbia	2	16	16	50.0								50.0			50.0								
			Saskatchewan	3	> 32	> 32	100.0													100.0						
			Ontario	4	> 32	> 32	100.0												25.0	75.0						
			Québec	5	> 32	> 32	100.0													100.0						
		Enterococcus spp.	British Columbia	2	> 32	> 32	100.0											50.0		50.0						
			Saskatchewan	5	> 32	> 32	100.0											20.0		80.0						
			Ontario	3	32	> 32	100.0											33.3	33.3	33.3						
			Québec	8	> 32	> 32	100.0											12.5	25.0	62.5						
	Penicillin	*E. faecalis*	British Columbia	38	4	4	0.0								39.5	60.5										
			Saskatchewan	68	4	4	0.0								29.4	70.6										
			Ontario	154	4	4	0.0								24.0	76.0										
			Québec	128	4	4	0.0								25.8	74.2										
		E. faecium	British Columbia	2	4	4	0.0								50.0	50.0										
			Saskatchewan	3	8	8	0.0								33.3		66.7									
			Ontario	4	4	16	25.0							25.0		50.0		25.0								
			Québec	5	16	> 16	100.0											60.0	40.0							
		Enterococcus spp.	British Columbia	2	1	1	0.0						50.0	50.0												
			Saskatchewan	5	≤ 0.5	16	20.0						60.0		20.0			20.0								
			Ontario	3	4	4	0.0						33.3			66.7										
			Québec	8	1	4	0.0						25.0	37.5		37.5										
	Streptomycin	*E. faecalis*	British Columbia	38	≤ 512	> 2048	26.3																73.7		2.6	23.7
II			Saskatchewan	68	≤ 512	> 2048	32.4																67.6		7.4	25.0
			Ontario	154	≤ 512	> 2048	24.7																75.3	3.2	9.1	12.3
			Québec	128	≤ 512	> 2048	37.5																62.5	3.1	12.5	21.9
		E. faecium	British Columbia	2	≤ 512	≤ 512	0.0																100.0			
			Saskatchewan	3	≤ 512	≤ 512	0.0																100.0			
			Ontario	4	≤ 512	1024	25.0																75.0	25.0		
			Québec	5	≤ 512	1024	20.0																80.0	20.0		
		Enterococcus spp.	British Columbia	2	1024	1024	50.0																50.0	50.0		
			Saskatchewan	5	≤ 512	> 2048	20.0																80.0			20.0
			Ontario	3	≤ 512	≤ 512	0.0																100.0			
			Québec	8	≤ 512	> 2048	25.0																75.0			25.0
	Tylosin	*E. faecalis*	British Columbia	38	2	> 32	47.4							2.6	50.0					47.4						
			Saskatchewan	68	2	> 32	44.1							5.9	45.6	4.4				44.1						
			Ontario	154	2	> 32	39.6							5.2	52.6	2.6				39.6						
			Québec	128	4	> 32	47.7							2.3	47.7	2.3				47.7						
		E. faecium	British Columbia	2	4	4	0.0									100.0										
			Saskatchewan	3	> 32	> 32	100.0													100.0						
			Ontario	4	8	> 32	25.0							25.0	25.0		25.0			25.0						
			Québec	5	4	> 32	20.0								20.0	40.0	20.0			20.0						
		Enterococcus spp.	British Columbia	2	2	2	0.0							50.0	50.0											
			Saskatchewan	5	8	> 32	40.0							20.0	20.0		20.0			40.0						
			Ontario	3	4	> 32	33.3								33.3	33.3				33.3						
			Québec	8	4	> 32	37.5							12.5	37.5	12.5				37.5						
	Chloramphenicol	*E. faecalis*	British Columbia	38	8	16	2.6									13.2	76.3	7.9		2.6						
			Saskatchewan	68	8	8	1.5										91.2	7.4		1.5						
			Ontario	154	8	8	0.6									3.2	93.5	2.6		0.6						
			Québec	128	8	8	4.7									4.7	85.9	4.7		4.7						
		E. faecium	British Columbia	2	4	4	0.0									100.0										
			Saskatchewan	3	8	8	0.0									33.3	66.7									
			Ontario	4	8	8	0.0									50.0	50.0									
			Québec	5	4	8	0.0									80.0	20.0									
		Enterococcus spp.	British Columbia	2	4	4	0.0									100.0										
			Saskatchewan	5	4	8	0.0									80.0	20.0									
			Ontario	3	8	8	0.0									33.3	66.7									
			Québec	8	4	32	12.5									62.5	25.0		12.5							
	Nitrofurantoin	*E. faecalis*	British Columbia	38	8	16	0.0										63.2	28.9	2.6	5.3						
			Saskatchewan	68	8	16	0.0										55.9	42.6		1.5						
			Ontario	154	8	16	0.6									1.3	54.5	34.4	6.5	2.6	0.6					
			Québec	128	8	16	0.0										65.6	29.7	3.1	1.6						
		E. faecium	British Columbia	2	64	64	0.0												50.0	50.0						
III			Saskatchewan	3	64	> 64	33.3													66.7	33.3					
			Ontario	4	64	64	0.0													100.0						
			Québec	5	> 64	> 64	100.0														100.0					
		Enterococcus spp.	British Columbia	2	> 64	> 64	50.0												50.0		50.0					
			Saskatchewan	5	32	> 64	40.0											40.0	20.0		40.0					
			Ontario	3	> 64	> 64	66.7											33.3			66.7					
			Québec	8	32	> 64	37.5										50.0		12.5		37.5					
	Tetracycline	*E. faecalis*	British Columbia	38	> 32	> 32	86.8									13.2			5.3	81.6						
			Saskatchewan	68	> 32	> 32	91.2									8.8			10.3	80.9						
			Ontario	154	> 32	> 32	90.3									9.7		1.9	11.7	76.6						
			Québec	128	> 32	> 32	87.5									12.5			10.2	77.3						
		E. faecium	British Columbia	2	≤ 4	≤ 4	0.0									100.0										
			Saskatchewan	3	> 32	> 32	100.0												33.3	66.7						
			Ontario	4	> 32	> 32	100.0												25.0	75.0						
			Québec	5	> 32	> 32	100.0												20.0	80.0						
		Enterococcus spp.	British Columbia	2	> 32	> 32	50.0									50.0				50.0						
			Saskatchewan	5	> 32	> 32	60.0									40.0				60.0						
			Ontario	3	> 32	> 32	66.7									33.3				66.7						
			Québec	8	> 32	> 32	87.5									12.5				87.5						
	Flavomycin	*E. faecalis*	British Columbia	38	≤ 1	≤ 1	0.0							94.7	5.3											
			Saskatchewan	68	≤ 1	≤ 1	0.0							100.0												
			Ontario	154	≤ 1	≤ 1	0.0							98.7	1.3											
			Québec	128	≤ 1	≤ 1	0.0							100.0												
		E. faecium	British Columbia	2	> 16	> 16	50.0											50.0	50.0							
IV			Saskatchewan	3	4	> 16	33.3							33.3		33.3			33.3							
			Ontario	4	16	> 16	25.0								25.0		25.0	25.0	25.0							
			Québec	5	2	> 16	20.0							20.0	40.0	20.0			20.0							
		Enterococcus spp.	British Columbia	2	> 16	> 16	50.0								50.0				50.0							
			Saskatchewan	5	≤ 1	4	0.0							80.0		20.0										
			Ontario	3	4	> 16	33.3								33.3	33.3			33.3							
			Québec	8	4	> 16	25.0							50.0		25.0			25.0							

[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Table B.2.12. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance*, 2007.

	Antimicrobial	n	Percentile		% 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	> 256
I	Amoxicillin-clavulanic acid	110	≤ 1	16	0.0							64.5	6.4	1.8	15.5	11.8					
	Ceftiofur	110	1	1	0.0						19.1	78.2	2.7								
	Ceftriaxone	110	≤ 0.25	≤ 0.25	0.0					100.0											
	Ciprofloxacin	110	≤ 0.015	0.03	0.0	80.0	19.1	0.9													
II	Amikacin	110	1	2	0.0						10.0	60.0	27.3	2.7							
	Ampicillin	110	≤ 1	> 32	30.9							59.1	9.1	0.9			0.9	30.0			
	Cefoxitin	110	2	4	0.0							10.9	40.0	44.5	3.6	0.9					
	Gentamicin	110	≤ 0.25	0.50	0.0					54.5	44.5	0.9									
	Kanamycin	110	≤ 8	> 64	12.7										87.3				12.7		
	Nalidixic acid	110	4	4	0.0							0.9	20.9	72.7	5.5						
	Streptomycin	110	≤ 32	> 64	37.3												62.7	13.6	23.6		
	Trimethoprim-sulfamethoxazole	110	≤ 0.12	1	8.2				59.1	24.5	5.5	2.7			8.2						
III	Chloramphenicol	110	8	> 32	21.8									15.5	60.0	2.7		21.8			
	Sulfisoxazole	110	64	> 256	38.2											11.8	35.5	13.6	0.9		38.2
	Tetracycline	110	32	> 32	50.9									49.1			9.1	41.8			
IV																					

Table B.2.13. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2007.

	Antimicrobial	n	Percentile		% 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	> 256
I	Amoxicillin-clavulanic acid	105	≤ 1	16	1.0							61.9	9.5		18.1	9.5		1.0			
	Ceftiofur	105	1	1	1.0						12.4	79.0	7.6			1.0					
	Ceftriaxone	105	≤ 0.25	≤ 0.25	0.0					99.0						1.0					
	Ciprofloxacin	105	≤ 0.015	0.03	0.0	66.7	29.5	3.8													
II	Amikacin	105	1	2	0.0						6.7	55.2	35.2	2.9							
	Ampicillin	105	≤ 1	> 32	28.6							58.1	11.4	1.9				28.6			
	Cefoxitin	105	4	4	1.0							1.0	45.7	46.7	3.8	1.9		1.0			
	Gentamicin	105	0.50	1	5.7					46.7	42.9	4.8				3.8	1.9				
	Kanamycin	105	≤ 8	> 64	14.3										85.7			1.9	12.4		
	Nalidixic acid	105	4	4	0.0								26.7	66.7	4.8	1.9					
	Streptomycin	105	≤ 32	> 64	44.8												55.2	17.1	27.6		
	Trimethoprim-sulfamethoxazole	105	≤ 0.12	0.50	5.7				54.3	26.7	10.5	1.9	1.0		5.7						
III	Chloramphenicol	105	8	> 32	25.7								1.9	11.4	55.2	5.7	1.0	24.8			
	Sulfisoxazole	105	64	> 256	45.7											9.5	26.7	16.2	1.9		45.7
	Tetracycline	105	32	> 32	55.2									44.8		1.0	12.4	41.9			
IV																					

Table B.2.14. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Salmonella* isolates from pigs; *Surveillance of Animal Clinical Isolates*, 2007.

	Antimicrobial	n	Percentile		% 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	> 256
I	Amoxicillin-clavulanic acid	187	2	16	2.1							38.0	15.0	1.6	11.8	31.6	1.1	1.1			
	Ceftiofur	187	1	2	2.1						4.8	83.4	9.6			2.1					
	Ceftriaxone	187	≤ 0.25	≤ 0.25	0.0					97.9						1.1	1.1				
	Ciprofloxacin	187	≤ 0.015	0.03	0.0	84.0	11.8	4.3													
II	Amikacin	187	1	2	0.0						1.6	59.4	35.8	2.7	0.5						
	Ampicillin	187	32	> 32	50.3							38.0	5.9	3.2		2.7	2.7	47.6			
	Cefoxitin	187	4	8	2.1							2.7	47.1	39.0	6.4	2.7		2.1			
	Gentamicin	187	0.50	0.50	2.7					42.8	50.8	3.2			0.5	0.5	2.1				
	Kanamycin	187	≤ 8	> 64	28.9										71.1				28.9		
	Nalidixic acid	187	4	4	0.0								42.8	49.2	8.0						
	Streptomycin	187	64	> 64	56.1												43.9	27.3	28.9		
	Trimethoprim-sulfamethoxazole	187	0.25	> 4	19.3				41.2	30.5	8.6	0.5			19.3						
III	Chloramphenicol	187	8	> 32	39.0								1.1	5.9	46.5	7.5		39.0			
	Sulfisoxazole	187	> 256	> 256	66.8											3.7	22.5	7.0			66.8
	Tetracycline	187	> 32	> 32	70.6									28.9	0.5		15.0	55.6			
IV																					

Table B.2.15. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	1,575	4	8	1.4							4.1	28.0	38.5	26.8	1.2	1.3	0.1			
	Ceftiofur	1,575	0.25	0.50	0.4				5.1	57.2	36.2	0.7	0.2	0.2	0.2	0.3					
	Ceftriaxone	1,575	≤ 0.25	≤ 0.25	0.0					98.7	0.4	0.3		0.1	0.3	0.2					
	Ciprofloxacin	1,575	≤ 0.015	≤ 0.015	0.0	98.4	1.3	0.1		0.2											
II	Amikacin	1,575	2	4	0.0						2.5	29.0	57.7	9.7	1.1						
	Ampicillin	1,575	2	> 32	35.1							14.1	36.8	11.9	1.6	0.6	0.6	34.5			
	Cefoxitin	1,575	4	8	0.8						0.4	1.3	30.6	57.5	8.4	1.0	0.2	0.6			
	Gentamicin	1,575	0.50	1	0.7					20.8	64.8	12.4	0.6	0.2	0.6	0.4	0.3				
	Kanamycin	1,575	≤ 8	> 64	14.7										84.3	0.9	0.1	0.6	14.2		
	Nalidixic acid	1,575	2	2	0.3						0.8	15.1	76.4	7.2	0.1	0.1	0.1	0.2			
	Streptomycin	1,575	≤ 32	> 64	33.8												66.2	16.0	17.8		
	Trimethoprim-sulfamethoxazole	1,575	≤ 0.12	> 4	10.9				53.7	27.2	7.2	0.8	0.3	0.1	10.7						
III	Chloramphenicol	1,575	8	32	19.0								2.9	37.0	36.0	5.0	10.2	8.8			
	Sulfisoxazole	1,575	64	> 256	49.6											44.4	4.6	1.3	0.1	0.1	49.6
	Tetracycline	1,575	> 32	> 32	78.5									21.2	0.3	0.3	4.0	74.2			
IV																					

Table B.2.16. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Escherichia coli* isolates from pigs; *Abattoir Surveillance*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	93	4	8	1.1							4.3	21.5	35.5	35.5	2.2		1.1			
	Ceftiofur	93	0.25	0.50	1.1				3.2	64.5	31.2				1.1						
	Ceftriaxone	93	≤ 0.25	≤ 0.25	0.0					98.9					1.1						
	Ciprofloxacin	93	≤ 0.015	≤ 0.015	0.0	100.0															
II	Amikacin	93	2	2	0.0						1.1	32.3	61.3	4.3	1.1						
	Ampicillin	93	4	> 32	36.6							16.1	28.0	17.2	1.1	1.1	1.1	35.5			
	Cefoxitin	93	4	4	1.1							2.2	38.7	55.9	2.2			1.1			
	Gentamicin	93	0.50	0.50	0.0					18.3	72.0	8.6	1.1								
	Kanamycin	93	≤ 8	> 64	18.3										80.6		1.1	1.1	17.2		
	Nalidixic acid	93	2	4	0.0							8.6	80.6	10.8							
	Streptomycin	93	≤ 32	> 64	33.3												66.7	10.8	22.6		
	Trimethoprim-sulfamethoxazole	93	0.25	> 4	11.8				38.7	43.0	5.4	1.1			11.8						
III	Chloramphenicol	93	8	32	16.1								2.2	38.7	37.6	5.4	9.7	6.5			
	Sulfisoxazole	93	32	> 256	49.5											46.2	4.3				49.5
	Tetracycline	93	> 32	> 32	75.3									24.7		1.1	5.4	68.8			
IV																					

Table B.2.17. Distribution of minimum inhibitory concentrations (MICs; μg/mL) for antimicrobials in *Escherichia coli* isolates from pork, by province; *Retail Meat Surveillance*, 2007.

	Antimicrobial	Province	n	Percentile		% 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	> 256
	Amoxicillin-clavulanic acid	British Columbia	23	4	4	0.0							4.3	39.1	47.8	8.7						
		Saskatchewan	38	4	4	2.6							5.3	26.3	60.5	2.6	2.6	2.6				
		Ontario	172	4	8	1.2							4.7	23.8	50.6	19.8		0.6	0.6			
		Québec	64	4	8	0.0							1.6	23.4	57.8	17.2						
	Ceftiofur	British Columbia	23	0.25	0.50	0.0				4.3	73.9	21.7										
		Saskatchewan	38	0.25	0.50	2.6				2.6	71.1	21.1	2.6			2.6						
		Ontario	172	0.25	0.50	0.6				8.1	42.4	46.5	1.7		0.6	0.6						
I		Québec	64	0.25	0.50	0.0				4.7	57.8	37.5										
	Ceftriaxone	British Columbia	23	≤ 0.25	≤ 0.25	0.0					100.0											
		Saskatchewan	38	≤ 0.25	≤ 0.25	0.0					97.4					2.6						
		Ontario	172	≤ 0.25	≤ 0.25	0.0					98.8				0.6	0.6						
		Québec	64	≤ 0.25	≤ 0.25	0.0					98.4	1.6										
	Ciprofloxacin	British Columbia	23	≤ 0.015	≤ 0.015	0.0	100.0															
		Saskatchewan	38	≤ 0.015	≤ 0.015	0.0	97.4	2.6														
		Ontario	172	≤ 0.015	≤ 0.015	0.0	98.8	0.6			0.6											
		Québec	64	≤ 0.015	≤ 0.015	0.0	100.0															
	Amikacin	British Columbia	23	2	4	0.0							21.7	65.2	13.0							
		Saskatchewan	38	2	4	0.0							36.8	52.6	5.3	5.3						
		Ontario	172	2	4	0.0						0.6	22.1	62.2	14.5	0.6						
		Québec	64	2	4	0.0							23.4	65.6	10.9							
	Ampicillin	British Columbia	23	2	> 32	13.0							4.3	60.9	21.7				13.0			
		Saskatchewan	38	2	4	5.3							15.8	60.5	18.4				5.3			
		Ontario	172	2	> 32	23.3							15.1	41.9	19.8				23.3			
		Québec	64	2	> 32	20.3							9.4	53.1	15.6	1.6			20.3			
	Cefoxitin	British Columbia	23	4	4	0.0							4.3	34.8	56.5	4.3						
		Saskatchewan	38	4	4	2.6							5.3	42.1	44.7	5.3		2.6				
		Ontario	172	4	4	1.2						0.6	1.7	29.7	61.0	5.8		0.6	0.6			
		Québec	64	4	4	0.0								35.9	57.8	6.3						
	Gentamicin	British Columbia	23	0.50	0.50	0.0					4.3	87.0	8.7									
		Saskatchewan	38	0.50	1	0.0					15.8	73.7	10.5									
		Ontario	172	0.50	1	0.6					15.7	68.6	15.1				0.6					
		Québec	64	0.50	1	1.6					15.6	59.4	21.9	1.6			1.6					
II	Kanamycin	British Columbia	23	≤ 8	≤ 8	0.0										95.7		4.3				
		Saskatchewan	38	≤ 8	≤ 8	0.0										97.4	2.6					
		Ontario	172	≤ 8	≤ 8	6.4										93.0	0.6			6.4		
		Québec	64	≤ 8	≤ 8	3.1										96.9				3.1		
	Nalidixic acid	British Columbia	23	2	2	0.0							17.4	82.6								
		Saskatchewan	38	2	2	0.0							13.2	78.9	7.9							
		Ontario	172	2	4	0.6							16.3	72.1	11.0				0.6			
		Québec	64	2	2	0.0							17.2	78.1	4.7							
	Streptomycin	British Columbia	23	≤ 32	64	13.0												87.0	4.3	8.7		
		Saskatchewan	38	≤ 32	≤ 32	5.3												94.7	5.3			
		Ontario	172	≤ 32	64	20.9												79.1	12.8	8.1		
		Québec	64	≤ 32	64	23.4												76.6	14.1	9.4		
	Trimethoprim-sulfamethoxazole	British Columbia	23	≤ 0.12	0.25	0.0				82.6	17.4											
		Saskatchewan	38	≤ 0.12	0.25	5.3				68.4	26.3					5.3						
		Ontario	172	≤ 0.12	0.50	4.7				63.4	25.0	5.8	1.2			4.7						
		Québec	64	≤ 0.12	0.25	3.1				70.3	23.4	3.1				3.1						
	Chloramphenicol	British Columbia	23	4	8	0.0								8.7	65.2	21.7	4.3					
		Saskatchewan	38	8	8	2.6								7.9	42.1	42.1	5.3	2.6				
		Ontario	172	4	16	8.1								3.5	51.7	32.0	4.7	5.2	2.9			
		Québec	64	8	8	6.3								3.1	45.3	43.8	1.6	4.7	1.6			
	Sulfisoxazole	British Columbia	23	≤ 16	> 256	13.0											78.3	4.3	4.3			13.0
		Saskatchewan	38	≤ 16	> 256	13.2											84.2	2.6				13.2
III		Ontario	172	≤ 16	> 256	23.8											70.3	5.2	0.6			23.8
		Québec	64	≤ 16	> 256	21.9											76.6	1.6				21.9
	Tetracycline	British Columbia	23	≤ 4	> 32	34.8									65.2			4.3	30.4			
		Saskatchewan	38	≤ 4	> 32	23.7									76.3			5.3	18.4			
		Ontario	172	≤ 4	> 32	45.9									53.5	0.6		4.7	41.3			
		Québec	64	≤ 4	> 32	45.3									54.7			3.1	42.2			
IV																						

Table B.2.18. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Enterococcus* isolates from pigs, by *Enterococcus* species; *Farm Surveillance*, 2007.

	Antimicrobial	Species	n	Percentile MIC 50	Percentile MIC 90	% R	≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2,048
I	Ciprofloxacin	*E. faecalis*	649	1	2	0.5					0.2	5.9	71.3	22.2	0.3	0.2									
	Ciprofloxacin	*E. faecium*	44	1	4	15.9						15.9	43.2	25.0	13.6	2.3									
	Ciprofloxacin	*Enterococcus* spp.	292	0.5	2	1.0					9.9	46.9	32.2	9.9	0.3	0.7									
	Daptomycin	*E. faecalis*	649	1	1	0.0						19.4	72.3	7.7	0.3	0.3									
	Daptomycin	*E. faecium*	44	2	8	0.0						11.4	18.2	22.7	36.4	11.4									
	Daptomycin	*Enterococcus* spp.	292	1	4	0.0						32.2	26.7	28.8	12.0	0.3									
	Linezolid	*E. faecalis*	649	2	2	0.0						3.1	30.2	66.6	0.2										
	Linezolid	*E. faecium*	44	2	2	0.0						2.3	13.6	84.1											
	Linezolid	*Enterococcus* spp.	292	1	2	0.0						13.0	42.1	44.9											
	Quinupristin-dalfopristin[a]	*E. faecium*	44	2	8	27.3							20.5	52.3	15.9	9.1	2.3								
	Quinupristin-dalfopristin	*Enterococcus* spp.	292	2	8	47.3							20.9	31.8	27.4	18.2	1.7								
	Tigecycline	*E. faecalis*	300	0.25	0.25	0.0	53.8		1.2	20.8	22.3	1.8													
	Tigecycline	*E. faecium*	34	0.12	0.25	0.0	22.7		18.2	36.4	22.7														
	Tigecycline	*Enterococcus* spp.	143	0.12	0.25	0.0	51.0		8.6	24.0	15.8	0.7													
	Vancomycin	*E. faecalis*	649	1	2	0.0						5.5	74.7	19.4	0.3										
	Vancomycin	*E. faecium*	44	0.5	1	0.0						72.7	18.2	4.5	4.5										
	Vancomycin	*Enterococcus* spp.	292	0.5	2	0.0						57.9	26.0	7.9	4.1	4.1									
II	Erythromycin	*E. faecalis*	649	16	16	74.9						7.2	13.1	4.6	0.2	0.5	74.4								
	Erythromycin	*E. faecium*	44	2	16	38.6						20.5	22.7	18.2			38.6								
	Erythromycin	*Enterococcus* spp.	292	16	16	68.8						25.7	2.4	1.4	1.7	0.7	68.2								
	Gentamicin	*E. faecalis*	649	128	128	7.7														90.8	1.5	4.2	1.7	1.8	
	Gentamicin	*E. faecium*	44	128	128	0.0														100.0					
	Gentamicin	*Enterococcus* spp.	292	128	128	0.7														99.0	0.3	0.7			
	Kanamycin	*E. faecalis*	649	128	2048	32.4														66.4	0.6	0.6	0.3	32.0	
	Kanamycin	*E. faecium*	44	128	512	6.8														79.5	9.1	4.5		6.8	
	Kanamycin	*Enterococcus* spp.	292	128	2048	22.3														76.4	1.0	0.3	0.3	21.9	
	Lincomycin[a]	*E. faecium*	44	32	64	86.4							9.1	2.3	2.3		31.8	11.4	43.2						
	Lincomycin	*Enterococcus* spp.	292	64	64	97.3							1.7	0.7	0.3	1.0	11.0	7.2	78.1						
	Penicillin	*E. faecalis*	649	4	4	0.5						3.9	0.8	19.0	74.9	1.1	0.3	0.2							
	Penicillin	*E. faecium*	44	2	8	4.5						15.9	20.5	25.0	27.3	6.8	4.5								
	Penicillin	*Enterococcus* spp.	292	1	8	9.2						31.8	21.9	9.9	16.1	11.0	4.1	5.1							
	Streptomycin	*E. faecalis*	649	512	> 2048	44.5																55.5	1.7	15.6	27.3
	Streptomycin	*E. faecium*	44	512	1024	11.4																88.6	2.3	4.5	4.5
	Streptomycin	*Enterococcus* spp.	292	512	> 2048	30.1																69.9	7.9	8.6	13.7
	Tylosin	*E. faecalis*	649	64	64	75.2					0.2	0.2	4.9	17.9	1.5	0.2		0.2	75.0						
	Tylosin	*E. faecium*	44	4	64	38.6							6.8	22.7	22.7	6.8	2.3		38.6						
	Tylosin	*Enterococcus* spp.	292	64	64	70.5					1.0	4.1	4.5	15.8	2.7	1.0	0.3	0.3	70.2						
III	Chloramphenicol	*E. faecalis*	649	8	32	10.2									7.1	78.1	4.6	2.6	7.6						
	Chloramphenicol	*E. faecium*	44	8	8	2.3									40.9	54.5	2.3		2.3						
	Chloramphenicol	*Enterococcus* spp.	292	8	8	5.1								1.7	41.4	50.0	1.7	3.1	2.1						
	Nitrofurantoin	*E. faecalis*	649	8	16	3.1								0.5	1.4	77.7	13.7	2.2	1.5	3.1					
	Nitrofurantoin	*E. faecium*	44	64	64	2.3									2.3	15.9	20.5	11.4	47.7	2.3					
	Nitrofurantoin	*Enterococcus* spp.	292	32	128	20.5								0.3	4.8	20.9	9.6	29.8	14.0	20.5					
	Tetracycline	*E. faecalis*	649	64	64	92.6									6.6	0.8	0.6	3.7	88.3						
	Tetracycline	*E. faecium*	44	4	64	38.6									61.4		4.5	2.3	31.8						
	Tetracycline	*Enterococcus* spp.	292	64	64	83.2									13.7	3.1	4.8	7.9	70.5						
IV	Flavomycin	*E. faecalis*	649	1	1	2.2							93.5	3.1	0.6	0.3	0.3	2.2							
	Flavomycin	*E. faecium*	44	32	32	72.7							13.6		4.5	6.8	2.3	72.7							
	Flavomycin	*Enterococcus* spp.	292	32	32	51.4							31.8	5.8	4.5	3.8	2.7	51.4							

[a] Resistance to quinupristin-dalfopristin and lincomycin is not reported for *E. faecalis* because *E. faecalis* is intrinsically resistant to these antimicrobials.

Table B.2.19. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from turkeys; *Surveillance of Animal Clinical Isolates*, 2007.

	Antimicrobial	n	Percentile MIC 50	Percentile MIC 90	% R	≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	Amoxicillin-clavulanic acid	49	16	> 32	49.0							40.8	4.1		4.1	2.0	6.1	42.9			
	Ceftiofur	49	2	> 8	49.0						10.2	38.8	2.0			49.0					
	Ceftriaxone	49	≤ 0.25	32	0.0					51.0						32.7	16.3				
	Ciprofloxacin	49	≤ 0.015	≤ 0.015	0.0	95.9	4.1														
II	Amikacin	49	2	2	0.0						6.1	42.9	51.0								
	Ampicillin	49	> 32	> 32	55.1							40.8	4.1					55.1			
	Cefoxitin	49	8	> 32	49.0							10.2	18.4	20.4	2.0		12.2	36.7			
	Gentamicin	49	0.50	> 16	20.4					34.7	42.9		2.0			2.0	18.4				
	Kanamycin	49	≤ 8	64	14.3										81.6	2.0	2.0	8.2	6.1		
	Nalidixic acid	49	4	4	0.0								28.6	71.4							
	Streptomycin	49	≤ 32	> 64	32.7												67.3	20.4	12.2		
	Trimethoprim-sulfamethoxazole	49	≤ 0.12	0.25	2.0				73.5	24.5					2.0						
III	Chloramphenicol	49	8	8	2.0								2.0	24.5	67.3	4.1		2.0			
	Sulfisoxazole	49	32	> 256	22.4											26.5	44.9	6.1			22.4
	Tetracycline	49	≤ 4	> 32	42.9									57.1				42.9			
IV																					

Table B.2.20. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from horses; *Surveillance of Animal Clinical Isolates*, 2007.

	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	> 256
I	Amoxicillin-clavulanic acid	67	16	16	0.0							16.4		1.5	31.3	50.7					
	Ceftiofur	67	1	4	3.0						7.5	82.1		7.5	3.0						
	Ceftriaxone	67	≤ 0.25	4	0.0					89.6				7.5	3.0						
	Ciprofloxacin	67	0.25	0.25	0.0	34.3				65.7											
II	Amikacin	67	16	32	1.5							17.9	10.4		13.4	46.3	10.4	1.5			
	Ampicillin	67	> 32	> 32	83.6							16.4						83.6			
	Cefoxitin	67	1	2	0.0							59.7	37.3	3.0							
	Gentamicin	67	> 16	> 16	79.1					6.0	13.4	1.5					79.1				
	Kanamycin	67	> 64	> 64	80.6										19.4				80.6		
	Nalidixic acid	67	8	16	0.0								9.0	25.4	43.3	22.4					
	Streptomycin	67	≤ 32	64	13.4												86.6	9.0	4.5		
	Trimethoprim-sulfamethoxazole	67	> 4	> 4	76.1				19.4	4.5					76.1						
III	Chloramphenicol	67	> 32	> 32	59.7									6.0	34.3			59.7			
	Sulfisoxazole	67	> 256	> 256	80.6											6.0	11.9	1.5			80.6
	Tetracycline	67	≤ 4	≤ 4	3.0									97.0			1.5	1.5			
IV																					

Table B.2.21. Distribution of minimum inhibitory concentrations (MICs; µg/mL) for antimicrobials in *Salmonella* isolates from feed; *Surveillance of Feed and Feed ingredients*, 2007.

	Antimicrobial	n	Percentile		% 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	> 256
I	Amoxicillin-clavulanic acid	179	≤ 1	≤ 1	1.7							95.0	2.8		0.6			1.7			
	Ceftiofur	179	1	1	1.7					0.6	32.4	65.4			0.6	1.1					
	Ceftriaxone	179	≤ 0.25	≤ 0.25	0.0					98.3					0.6	1.1					
	Ciprofloxacin	179	≤ 0.015	0.03	0.0	87.2	12.8														
II	Amikacin	179	1	4	0.0						6.7	45.3	16.2	31.3	0.6						
	Ampicillin	179	≤ 1	2	2.2							62.6	35.2					2.2			
	Cefoxitin	179	4	4	1.7						0.6	2.8	26.8	63.1	5.0		1.7				
	Gentamicin	179	≤ 0.25	0.50	0.6					52.0	42.5	4.5	0.6				0.6				
	Kanamycin	179	≤ 8	16	0.0										69.8	30.2					
	Nalidixic acid	179	4	4	0.0							0.6	20.7	75.4	3.4						
	Streptomycin	179	≤ 32	64	10.6												89.4	5.0	5.6		
	Trimethoprim-sulfamethoxazole	179	≤ 0.12	0.25	0.6				88.8	9.5	1.1				0.6						
III	Chloramphenicol	179	8	8	2.8								1.1	31.8	64.2			2.8			
	Sulfisoxazole	179	32	128	3.9											21.8	29.1	16.8	28.5		3.9
	Tetracycline	179	≤ 4	8	7.8									65.9	26.3		3.4	4.5			
IV																					

B.3 Antimicrobial Use in Humans

Table B.3.1. Total volume of active ingredients of oral antimicrobials dispensed by retail pharmacies in Canada, 2000–2007.

ATC Class			Total amount of active ingredients (Kg)							
			2000	2001	2002	2003	2004	2005	2006	2007
I	J01CR	Combinations of penicillins, including ß-lactamase inhibitors	7,148.28	7,295.71	7,114.06	7,492.67	7,491.56	8,414.31	8,985.63	9,798.46
I	J01DD	Third-generation cephalosporins	441.47	412.56	372.50	321.45	275.37	282.37	274.85	303.36
I	J01MA	Fluoroquinolones	17,387.35	17,569.37	17,718.15	18,469.28	18,738.69	18,781.31	19,348.84	19,788.30
I	J01XA	Glycopeptides	25.90	28.25	32.23	40.56	70.36	79.17	75.77	83.99
I	J01XD	Imidazole	NA	4,808.34	4,927.11	5,126.54	5,237.51	5,311.07	5,563.98	5,585.72
I	J01XX	Linezolid	NA	1.55	4.91	10.82	17.29	23.26	22.44	25.35
II	J01CA	Penicillins with extended spectrum	57,566.37	56,004.37	53,404.23	53,132.75	51,471.46	53,138.73	53,534.56	53,440.34
II	J01CE	ß-lactamase sensitive penicillins	15,079.86	14,253.92	13,722.26	13,802.13	12,916.80	13,174.53	13,139.62	12,879.95
II	J01CF	ß-lactamase resistant penicillins	8,351.00	8,004.27	7,376.34	7,135.18	6,596.38	5,861.06	5,604.86	5,157.50
II	J01DB	First-generation cephalosporins	16,693.30	17,295.99	18,358.43	19,683.24	20,312.94	21,585.02	22,981.10	23,345.75
II	J01DC	Second-generation cephalosporins	11,099.40	9,857.59	8,712.26	8,570.41	8,277.23	8,410.81	7,937.42	7,423.47
II	J01EE	Combinations of sulfonamides and trimethoprim, Including derivatives	26,196.41	23,815.65	21,549.97	20,179.30	19,226.17	18,858.59	18,520.09	18,079.24
II	J01FA	Macrolides	25,163.98	23,844.04	21,665.44	22,138.28	21,168.11	22,746.49	22,646.85	22,513.36
II	J01FF	Lincosamides	3,289.35	3,590.12	3,896.00	4,272.26	4,441.95	4,499.59	4,976.71	5,303.12
II	J01GB	Aminoglycosides	29.66	0.36	0.04	0.00	0.01	NA	0.05	0.20
II	J01MB	Other quinolones, excluding fluoroquinolones	76.31	62.19	52.12	45.35	41.87	1.05	0.26	0.02
II	J01RA	Sulfonamide combinations, excluding trimethoprim	2,745.17	1,910.05	1,251.28	843.14	548.87	494.05	418.86	305.33
II	J01XC	Steroid antimicrobials	34.79	39.06	35.54	37.27	36.64	41.91	42.73	34.21
III	J01AA	Tetracyclines	14,112.37	13,169.24	12,595.12	11,902.77	11,050.90	10,709.61	10,298.35	9,664.96
III	J01BA	Amphenicols	0.78	0.99	0.20	NA	0.06	0.01	NA	NA
III	J01EA	Trimethoprim, including derivatives	315.71	297.29	310.34	307.34	288.32	265.98	265.88	260.48
III	J01EB	Short-acting sulfonamides	105.38	13.45	0.88	1.04	1.02	0.26	0.13	0.03
III	J01EC	Intermediate-acting sulfonamides	28.08	4.48	4.77	5.55	4.51	2.93	2.27	2.36
III	J01XE	Nitrofuran derivatives	935.24	981.97	1,019.51	1,073.19	1,152.40	1,210.89	1,323.77	1,387.68
III	J01XX	Fosfomycin	64.76	74.26	48.00	35.71	26.28	20.78	17.80	11.01
NC	J01XX	Methenamine	389.51	356.69	350.35	296.88	282.20	253.34	249.14	256.85
	J01	**Total**	**207,280.44**	**203,691.77**	**194,522.04**	**194,923.13**	**189,674.87**	**194,167.12**	**196,231.93**	**195,651.06**

Roman numerals I to III indicate the ranking of antimicrobials based on importance in human medicine as outlined by the Veterinary Drugs Directorate.

ATC = Anatomical Therapeutic Chemical. NA = Not available. NC = Not classified.

B.4 Summary Tables for Human and Agri-Food Data

Table B.4.1. Summary of selected resistance patterns involving multiple antimicrobials in bacterial isolates from humans and the agri-food sector; CIPARS, 2007.

Species	Bacterial species	Number (%) of isolates/Serovar total Number (%) of isolates/ *Salmonella* total							
		Susceptible to all antimicrobials	Resistant to A2C-AMP	ACSSuT	AKSSuT	ACKSSuT	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
Surveillance of Human Clinical Isolates									
Humans	*Salmonella* Enteritidis (n = 910)	795/910 (87%) 795/3,308 (24%)			1/910 (< 1%) 1/3,308 (<1%)				
	S. Heidelberg (n = 319)	193/319 (60%) 193/3,308 (6%)	46/319 (14%) 46/3,308 (1%)				1/319 (< 1%) 1/3,308 (< 1%)		
	S. Newport (n = 127)	113/127 (89%) 113/3,308 (3%)		1/127 (1%) 1/3,308 (<1%)			2/127 (2%) 2/3,308 (<1%)		2/127 (2%) 2/3,308 (<1%)
	S. Typhi (n = 156)	30/156 (19%) 30/3,308 (1%)		16/156 (10%) 16/3,308 (< 1%)					
	S. Paratyphi A and B (n = 45)	12/45 (27%) 12/3,308 (<1%)		2/45 (4%) 2/3,308 (<1%)					
	S. Typhimurium (n = 658)	436/658 (66%) 436/3,308 (13%)	3/658 (< 1%) 3/3,308 (< 1%)	73/658 (11%) 73/3,308 (2%)	7/658 (1%) 7/3,308 (< 1%)	12/658 (2%) 12/3,308 (< 1%)	6/658 (1%) 6/3,308 (< 1%)		
	Other Serovars (n = 1,093)	847/1,093 (77%) 847/3,308 (26%)	8/1,093 (1%) 8/3,308 (<1%)	3/1,093 (< 1%) 3/3,308 (<1%)	2/1,093 (< 1%) 2/3,308 (<1%)	2/1,093 (< 1%) 2/3,308 (<1%)			
Farm Surveillance									
Pigs	*Escherichia coli* (n=1,575)	219/1,575 (14%)	4/1,575 (<1%)	45/1,575 (3%)	32/1,575 (3%)	14/1,575 (<1%)	1/1,575 (< 1%)		
	S. Derby (n = 21)	7/21 (33%) 7/110 (6%)			1/21 (5%) 1/110 (1%)				
	S. I 4:i:- (n = 7)	3/7 (43%) 3/110 (3%)		1/ 7 (14%) 1/110 (1%)		3/7 (43%) 3/110 (3%)			
	S. Typhimurium (n = 10)	7/110 (6%)		1/110 (1%)		5/110 (5%)			
	S. Typhimurium var. 5- (n = 22)	14/110 (13%)		6/110 (5%)	2/110 (2%)	2/110 (2%)			
	S. Typhimurium var. 5- (n = 22)	0/110 (0%)		1/110 (1%)		1/110 (1%)			
Abattoir Surveillance									
Beef cattle	*E. coli* (n = 188)	111/188 (59%)							
Chickens	*E. coli* (n = 180)	42/180 (23%)	35/180 (19%)				7/180 (4%)	3/180 (2%)	
	S. Enteritidis (n = 20)	19/20 (95%) 19/206 (9%)							
	S. Heidelberg (n = 37)	23/37 (62%) 23/206 (11%)	7/37 (19%) 7/206 (3%)						
	S. Typhimurium (n = 11)	6/11 (55%) 6/206 (3%)	2/11 (18%) 2/206 (< 1%)	3/11 (27%) 3/206 (1%)					
	Other serovars (n = 138)	46/138 (33%) 46/206 (22%)	13/138 (9%) 13/206 (6%)						
Pigs	*E. coli* (n = 93)	17/93 (18%)	1/93 (1%)	2/93 (2%)	4/93 (4%)	1/93 (1%)			
	S. Heidelberg (n = 3)								
	S. Typhimurium (n = 32)	4/32 (13%) 4/105 (4%)		17/32 (53%) 17/105 (16%)		4/32 (13%) 4/105 (4%)			
	Other serovars (n = 70)	36/70 (51%) 36/105 (34%)				2/70 (3%) 2/105 (2%)			1/70 (1%) 1/105 (< 1%)
Retail Meat Surveillance									
Beef	*E. coli* (n = 501)	432/501 (86%)		1/501 (< 1%)	1/501 (< 1%)	1/501 (< 1%)	1/501 (< 1%)		
Chicken	*E. coli* (n = 402)	107/402 (27%)	66/402 (16%)	2/402 (< 1%)	8/402 (2%)	1/402 (< 1%)	3/402 (< 1%)	1/402 (< 1%)	1/402 (< 1%)
	S. Enteritidis (n = 17)	17/17 (100%) 17/346 (5%)							
	S. Heidelberg (n = 87)	48/87 (55%) 48/346 (14%)	16/87 (18%) 16/346 (5%)						
	S. Typhimurium (n = 12)	10/12 (83%) 10/346 (3%)		1/12 (8%) 1/346 (1%)					
	Other serovars (n = 230)	92/230 (40%) 92/346 (27%)	18/230 (8%) 18/346 (5%)						
Pork	*E. coli* (n = 297)	162/297 (55%)	2/297 (< 1%)	3/297 (1%)	3/297 (1%)				

Results for each of the above specific patterns exclude isolates resistant to one of the other patterns presented in this table but may include isolates resistant to other antimicrobials. Blank cells represent values equal to zero (0%). For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium results (except for *Farm Surveillance*) to harmonize serovar classification with that of the National Microbiology Laboratory.

Table B.4.1 (continued). Summary of selected resistance patterns involving multiple antimicrobials in bacterial isolates from humans and the agri-food sector; CIPARS, 2007.

Species	Bacterial species	Number (%) of isolates/Serovar total Number (%) of isolates/ *Salmonella* total							
		Susceptible to all antimicrobials	Resistant to A2C-AMP	ACSSuT	AKSSuT	ACKSSuT	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
Surveillance of Animal Clinical Isolates									
Cattle	*S*. Heidelberg (n = 1)	1/1 (100%) 1/140 (<1%)							
	S. Typhimurium (n = 47)	19/47 (40%) 19/140 (14%)		7/47 (15%) 7/140 (5%)		10/47 (21%) 10/140 (7%)	1/47 (2%) 1/140 (< 1%)		2/47 (4%) 2/140 (1%)
	Other serovars (n = 92)	85/92 (92%) 85/140 (61%)							
Chickens	*S*. Enteritidis (n = 36)	36/36 (100%) 36/105 (34%)							
	S. Heidelberg (n = 21)	11/21 (52%) 11/105 (10%)	8/21 (38%) 8/105 (8%)						
	S. Typhimurium (n = 12)	11/12 (92%) 11/105 (10%)		1/12 (8%) 1/105 (<1%)					
	Other serovars (n = 36)	19/36 (53%) 19/105 (18%)	5/36 (14%) 5/105 (5%)					1/36 (3%) 1/105 (<1%)	
Pigs	*S*. Enteritidis (n = 2)	2/2 (100%) 2/187 (1%)							
	S. Heidelberg (n = 1)								
	S. Typhimurium (n = 104)	8/104 (8%) 8/187 (4%)		30/104 (29%) 30/187 (16%)	6/104 (6%) 6/187 (3%)	23/104 (22%) 23/187 (12%)			
	Other serovars (n = 80)	36/80 (45%) 36/187 (19%)	1/80 (1%) 1/187 (< 1%)	3/80 (4%) 3/187 (2%)	4/80 (5%) 4/187 (2%)	3/80 (4%) 3/187 (2%)	2/80 (3%) 2/187 (1%)		1/80 (< 1%) 1/187 (< 1%)
Turkeys	*S*. Enteritidis (n = 2)	2/2 (100%) 2/49 (4%)							
	S. Heidelberg (n = 8)	1/8 (13%) 1/49 (2%)	2/8 (25%) 2/49 (4%)						
	S. Typhimurium (n = 11)	1/11 (9%) 1/49 (2%)	10/11 (91%) 10/49 (20%)						
	Other serovars (n = 28)	3/28 (11%) 3/49 (6%)	9/28 (32%) 9/49 (18%)				1/28 (4%) 1/49 (2%)	2/28 (7%) 2/49 (4%)	
Horses	*S*. Heidelberg (n = 54)								
	S. Newport (n = 2)	2/2 (100%) 2/67 (3%)							
	S. Typhimurium (n = 5)	3/5 (60%) 3/67 (4%)		1/5 (20%) 1/66 (2%)	1/5 (20%) 1/66 (20%)				
	Other serovars (n = 6)	6/7 (100%) 6/67 (7%)							

Results for each of the above specific patterns exclude isolates resistant to one of the other patterns presented in this table but may include isolates resistant to other antimicrobials. Blank cells represent values equal to zero (0%). For the purpose of this table, *S*. Typhimurium var. 5- results were combined with *S*. Typhimurium results to harmonize serovar classification with that of the National Microbiology Laboratory.

Table B.4.2. Summary of antimicrobial susceptibility in the most common isolates of *Salmonella* serovars from humans and the agri-food sector; CIPARS, 2007.

	Most common serovars				
Species	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 15 antimicrobials in resistance pattern
Surveillance of Human Clinical Isolates					
Humans	**n = 3308**	**n = 2356**	**n = 763**	**n = 179**	**n = 10**
	Enteritidis (910)	Enteritidis (725)	Enteritidis (178)	Typhimurium (105)	Typhimurium (6)
	Typhimurium (658)	Typhimurium (436)	Heidelberg (121)	Typhi (32)	Newport (3)
	Heidelberg (319)	Heidelberg (193)	Typhimurium (111)	Enteritidis (7)	Choleraesuis (1)
	Typhi (156)	Newport (113)	Typhi (94)	Heidelberg (5)	
	Newport (127)	Thompson (92)	Hadar (72)	I 4,(5),12:i:- (4)	
	Thompson (94)	Oranienburg (77)	Paratyphi A (31)	Saintpaul (4)	
	I 4,(5),12:i:- (83)	I 5,(5),12:i:- (59)	Mbandaka (23)	Stanley (3)	
	Oranienburg (78)	Infantis (56)	I 4,(5),12:i:- (20)	Newport (2)	
Farm Surveillance					
Pigs	**n = 110**	**n = 49**	**n = 36**	**n = 25**	
	Typhimurium var. 5- (22)	Infantis (10)	Typhimurium var. 5- (8)	Typhimurium var. 5- (10)	
	Derby (21)	Derby (7)	Typhimurium (3)	Typhimurium (6)	
	Infantis (11)	Typhimurium var. 5- (4)	I 4:i:- (3)	I 4:i:- (4)	
	Typhimurium (10)	Orion (3)	California (2)		
	I 4:i:- (7)	California (3)	Brandenburg (2)		
	California (4)	I 4:-:- (2)	Mbandaka (2)		
	Heidelberg (4)	Johannesburg (2)			
	Brandenburg (3)	Krefeld (2)			
	Mbandaka (3)	London (2)			
	Orion (3)	Muenchen (2)			
		Heidelberg (2)			
Abattoir Surveillance					
Chickens	**n = 206**	**n = 94**	**n = 98**	**n = 14**	
	Kentucky (89)	Heidelberg (23)	Kentucky (57)	Kentucky (11)	
	Heidelberg (37)	Kentucky (21)	Heidelberg (14)	Typhimurium (2)	
	Enteritidis (20)	Enteritidis (19)	Hadar (9)	Typhimurium var. 5- (1)	
	Hadar (10)	Kiambu (4)	I4:i:- (4)		
	I4:i:- (7)	Thompson (4)	Kiambu (2)		
	Typhimurium (7)	Typhimurium (4)			
	Kiambu (6)	I4:i:- (3)			
		Agona (2)			
		Mbandaka (2)			
		Typhimurium var. 5- (2)			
Pigs	**n = 105**	**n = 40**	**n = 38**	**n = 26**	**n = 1**
	Derby (18)	Brandenburg (5)	Derby (15)	Typhimurium (12)	I4:i:- (1)
	Typhimurium (16)	Infantis (5)	Typhimurium var. 5- (5)	Typhimurium var. 5- (10)	
	Typhimurium var. 5- (16)	London (5)	Heidelberg (3)	I4:i:- (1)	
	Brandenburg (6)	Derby (3)	Agona (2)	Mbandaka (1)	
	Infantis (6)	Typhimurium (3)	California (2)	Ohio (1)	
	London (5)	Give (2)	I4:d:- (2)	Senftenberg (1)	
	Mbandaka (4)	Manhattan (2)	Krefeld (2)		
	Agona (3)	Mbandaka (2)	Altona (1)		
	California (3)	Agona (1)	Bovismorbificans (1)		
	Heidelberg (3)	Bredeney (1)	Brandenburg (1)		
	Krefeld (3)	California (1)	Infantis (1)		
		Havana (1)	Mbandaka (1)		
		I6,7:-:5 (1)	Typhimurium (1)		
		I6,7:-:z15 (1)	Worthington (1)		
		Kentucky (1)			
		Krefeld (1)			
		Litchfield (1)			
		Muenchen (1)			
		Orion (1)			
		Typhimurium var. 5- (1)			
		Worthington (1)			
Retail Meat Surveillance					
Chicken	**n = 346**	**n = 167**	**n = 169**	**n = 10**	
	Kentucky (110)	Heidelberg (48)	Kentucky (77)	Kentucky (6)	
	Heidelberg (87)	Kentucky (27)	Heidelberg (37)	Heidelberg (2)	
	Hadar (22)	Enteritidis (17)	Hadar (21)	Kiambu (1)	
	Enteritidis (17)	Thompson (16)	Schwarzengrund (7)	Typhimurium (1)	
	Thompson (16)	Infantis (11)	Kiambu (6)		
	Kiambu (14)	Typhimurium (9)			
	Infantis (11)	Kiambu (7)			
	Typhimurium (10)	Agona (4)			
	Schwarzengrund (9)				

Most common serovars were those representing 2% or more of the isolates within each surveillance component and species. For the *Surveillance of human clinical isolates*, *Salmonella* Typhimurium var. 5- results were combined with those of *S.* Typhimurium.

Table B.4.2 (continued). Summary of antimicrobial susceptibility in the most common isolates of *Salmonella* serovars from humans and the agri-food sector; CIPARS, 2007.

Species	Most common serovars				
	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 15 antimicrobials in resistance pattern
Surveillance of Animal Clinical Isolates					
Cattle	**n = 140**	**n = 105**	**n = 13**	**n = 20**	**n = 2**
	Typhimurium (35)	Kentucky (28)	Typhimurium var. 5- (4)	Typhimurium (14)	Typhimurium var5- (2)
	Kentucky (29)	Typhimurium (19)	Anatum (3)	Typhimurium var. 5- (6)	
	Cerro (13)	Cerro (12)	Typhimurium (2)		
	I6,14,18:-:- (11)	I6,14,18:-:- (11)	Cerro (1)		
	Typhimurium var. 5- (10)	Thompson (6)	Hadar (1)		
	Thompson (6)	I4:i:- (4)	I4:i:- (1)		
	I4:i:- (5)	Schwarzengrund (4)	Kentucky (1)		
	Schwarzengrund (4)	Infantis (3)			
	Anatum (3)	Montevideo (3)			
	Infantis (3)				
	Montevideo (3)				
Chickens	**n = 105**	**n = 77**	**n = 24**	**n = 3**	**n = 1**
	Enteritidis (36)	Enteritidis (36)	Heidelberg (10)	Kentucky (1)	Bredeney (1)
	Heidelberg (21)	Heidelberg (11)	I8,20:-:z6 (3)	Senftenberg (1)	
	Kentucky (12)	Typhimurium (9)	Kentucky (3)	Typhimurium (1)	
	Typhimurium (10)	Kentucky (8)	I4:i:- (2)		
	I4:i:- (6)	I4:i:- (4)	Infantis (2)		
	Infantis (4)	I-:gm:- (2)	Braenderup (1)		
	I8,20:-:z6 (3)	Infantis (2)	Hadar (1)		
		Typhimurium var. 5- (2)	IRough-O:k:- (1)		
			Thompson (1)		
Pigs	**n = 187**	**n = 46**	**n = 59**	**n = 79**	**n = 3**
	Typhimurium (66)	Derby (9)	Typhimurium (21)	Typhimurium (39)	Ohio (2)
	Typhimurium var. 5- (38)	Infantis (9)	Derby (12)	Typhimurium var. 5- (25)	Livingstone (1)
	Derby (25)	Typhimurium (6)	Typhimurium var. 5- (11)	Derby (4)	
	Infantis (9)	Brandenburg (3)	Schwarzengrund (3)	Albany (2)	
	Brandenburg (6)	Enteritidis (2)	Agona (2)	Ohio (2)	
	Schwarzengrund (5)	Schwarzengrund (2)	Brandenburg (2)		
	Mbandaka (4)	Tennessee (2)	Mbandaka (2)		
	Ohio (4)	Typhimurium var. 5- (2)			
		Worthington (2)			
		Alachua (1)			
		Anatum (1)			
		Berta (1)			
		Havana (1)			
		I-:r:5 (1)			
		I6,7:-:l,w (1)			
		London (1)			
		Mbandaka (1)			
		Soerenga (1)			
Turkeys	**n = 49**	**n = 7**	**n = 31**	**n = 8**	**n = 3**
	Typhimurium (10)	Enteritidis (2)	Typhimurium (9)	Senftenberg (3)	Bredeney (2)
	Heidelberg (8)	Brandenburg (1)	Heidelberg (5)	Agona (2)	Senftenberg (1)
	Senftenberg (7)	Heidelberg (1)	Hadar (4)	Heidelberg (2)	
	Agona (5)	Senftenberg (1)	Agona (3)	Typhimurium (1)	
	Hadar (4)	Thompson (1)	Anatum (2)		
	Anatum (2)	Typhimurium var. 5- (1)	Derby (2)		
	Bredeney (2)		I4:-:- (2)		
	Derby (2)		Senftenberg (2)		
	Enteritidis (2)		Albany (1)		
	I4:-:- (2)		I-:eh:5 (1)		
	Albany (1)				
	Brandenburg (1)				
	I-:eh:5 (1)				
	Thompson (1)				
	Typhimurium var. 5- (1)				
Horses	**n = 67**	**n = 11**	**n = 3**	**n = 53**	
	Heidelberg (54)	Typhimurium (3)	Heidelberg (3)	Heidelberg (51)	
	Typhimurium (5)	Newport (2)		Typhimurium (2)	
	Newport (2)	Rubislaw (2)			
	Rubislaw (2)	Give (1)			
		Hartford (1)			
		I4,[5],12:b:- (1)			
		Thompson (1)			

Most common serovars were those representing 2% or more of the isolates within each surveillance component and species.

Table B.4.3. Recovery rates for bacterial species of isolates from various surveillance components of the agri-food sector; CIPARS, 2002–2007.

CIPARS Component/ Animal species	Province	Year	*Escherichia coli* %	*Escherichia coli* n/N	*Salmonella* %	*Salmonella* n/N	*Campylobacter* %	*Campylobacter* n/N	*Enterococcus* %	*Enterococcus* n/N
Farm Surveillance										
Pigs		2006	**99%**	459/462	**20%**	94/462			**81%**	374/462
		2007	**100%**	612/612	**21%**	136/612			**81%**	495/612
Abattoir Surveillance										
Beef cattle		2002	**97%**	76/78	**1%**	3/78				
		2003	**97%**	155/159	**< 1 %**	1/114				
		2004	**98%**	167/170						
		2005	**97%**	122/126			**66%**	23/35		
		2006	**100%**	150/150			**36%**	31/87		
		2007	**99%**	188/190			**39%**	75/190		
Pigs		2002	**97%**	38/39	**27%**	103/385				
		2003	**98%**	153/155	**28%**	395/1393				
		2004	**99%**	142/143	**38%**	270/703				
		2005	**99%**	163/164	**42%**	212/486				
		2006	**98%**	115/117	**40%**	145/359				
		2007	**98%**	93/95	**36%**	105/296				
Chickens		2002	**100%**	40/40	**13%**	25/195				
		2003	**97%**	150/153	**16%**	126/803				
		2004	**99%**	130/131	**16%**	142/893				
		2005	**99%**	218/220	**18%**	200/1103				
		2006	**100%**	166/166	**23%**	187/824				
		2007	**99%**	180/181	**25%**	204/808				
Retail Meat Surveillance										
Beef	British Columbia	2005	**93%**	27/29						
		2007	**79%**	49/62						
	Saskatchewan	2005	**79%**	120/151						
		2006	**76%**	123/161						
		2007	**78%**	118/151						
	Ontario	2003	**66%**	101/154	**2%**	2/84	**3%**	2/76	**91%**	69/76
		2004	**80%**	190/237						
		2005	**81%**	184/227						
		2006	**81%**	189/235						
		2007	**71%**	184/227						
	Québec	2003	**57%**	84/147	**0%**	0/33	**0%**	0/33	**80%**	28/35
		2004	**56%**	137/245						
		2005	**56%**	126/225						
		2006	**50%**	109/215						
		2007	**68%**	147/216						
Pork	British Columbia	2005	**31%**	10/32						
		2007	**29%**	23/79	**1%**	1/79				
		2008	**30%**	44/148	**2%**	3/148				
	Saskatchewan	2005	**30%**	48/162						
		2006	**30%**	49/165	**2%**	3/134				
		2007	**25%**	38/154	**2%**	3/154				
	Ontario	2003	**58%**	90/154	**1%**	1/93	**0%**	0/76	**87%**	66/76
		2004	**71%**	198/279						
		2005	**59%**	179/303						
		2006	**59%**	182/311	**< 1%**	1/255				
		2007	**54%**	172/320	**2%**	6/319				
	Québec	2003	**42%**	61/147	**3%**	1/32	**9%**	3/32	**82%**	28/34
		2004	**38%**	109/290						
		2005	**26%**	79/300						
		2006	**20%**	57/287	**0%**	0/232				
		2007	**22%**	64/287	**1%**	3/288				

% Isolates recovered; Number of isolates recovered/number of samples submitted.

Results in the gray-shaded areas indicate isolates that were recovered but not submitted for antimicrobial susceptibility testing.

Table B.4.3 (continued). Recovery rates for bacterial species of isolates from various surveillance components of the agri-food sector; CIPARS, 2002–2007.

CIPARS Component/ Animal species	Province	Year	% Isolates recovered *Escherichia coli*	Number of isolates recovered/number of samples submitted	*Salmonella*		*Campylobacter*		*Enterococcus*	
Retail Meat Surveillance										
Chicken	British Columbia	2005	**95%**	19/20	**13%**	5/39	**69%**	27/39	**100%**	20/20
		2007	**98%**	42/43	**22%**[a]	18/81	**35%**	28/80	**100%**	34/34
	Saskatchewan	2005	**98%**	81/83	**14%**	21/153	**37%**	53/145	**98%**	83/85
		2006	**98%**	85/86	**16%**	25/153	**33%**	51/155	**98%**	85/87
		2007	**97%**	75/77	**31%**[a]	43/141	**35%**	49/141	**100%**	77/77
	Ontario	2003	**95%**	137/144	**16%**	27/167	**47%**	78/166	**99%**	143/144
		2004	**95%**	150/158	**17%**	54/315	**45%**	143/315	**100%**	158/158
		2005	**95%**	145/153	**9%**	26/303	**40%**	120/303	**99%**	150/152
		2006	**97%**	152/156	**12%**	36/311	**34%**	104/311	**98%**	154/156
		2007	**98%**	157/161	**54%**[a]	172/320	**37%**	117/320	**100%**	161/161
	Québec	2003	**89%**	112/126	**16%**	29/171	**55%**	94/170	**100%**	125/125
		2004	**96%**	157/161	**17%**	53/320	**50%**	161/322	**100%**	161/161
		2005	**95%**	142/149	**9%**	26/300	**34%**	103/299	**100%**	150/150
		2006	**94%**	135//144	**12%**	33/288	**35%**	100/288	**100%**	144/144
		2007	**90%**	129/144	**40%**[a]	113/287	**21%**	59/287	**99%**	143/144

Results in the gray-shaded areas indicate isolates that were recovered but not submitted for antimicrobial-resistance testing.

[a] Enhancement to *Salmonella* recovery method explains higher prevalence in isolates from retail chicken in 2007 than in prior years.

Table B.4.4. Distribution of animal isolates of *Salmonella*, by province; *Surveillance of Animal Clinical Isolates*, 2007.

Species	Alberta	Saskatchewan	Manitoba	Ontario	Québec	New Brunswick	Nova Scotia
	Number (%) of isolates						
Cattle (n = 140)	3 (2)	1 (1)	6 (4)	90 (64)	40 (29)		
Chickens (n = 105)	10 (10)		5 (5)	67 (64)	22 (21)	1 (1)	
Pigs (n = 187)	3 (2)	3 (2)	9 (5)	85 (45)	79 (42)		8 (5)
Turkeys (n = 49)	3 (6)			19 (39)	26 (53)		1 (2)
Horses (n = 67)	2 (3)			63 (94)	2 (3)		

Appendix C - Additional Information

C.1 Abbreviations

General abbreviations

A2C-AMP Resistance to amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and ampicillin

AAFC Agriculture and Agri-Food Canada

AARD Alberta Agriculture and Rural Development

ACSSuT Resistance to ampicillin, chloramphenicol, streptomycin, sulfisoxazole, and tetracycline

ACKSSuT Resistance to ampicillin, chloramphenicol, kanamycin, streptomycin, sulfisoxazole, and tetracycline

AKSSuT Resistance to ampicillin, kanamycin, streptomycin, sulfisoxazole, and tetracycline

AMR Antimicrobial resistance

ATC Anatomical Therapeutic Chemical

ATCC American Type Culture Collection

BPW Buffered peptone water

CAHI Canadian Animal Health Institute

CCS Canadian CompuScript

CI Confidence interval

CLSI Clinical and Laboratory Standards Institute

CQA® Canadian Quality Assurance

DANMAP Danish Integrated Antimicrobial Resistance Monitoring and Research Program

DDD Defined daily dose

ESAC European Surveillance of Antimicrobial Consumption

ESBL Extended-spectrum β-lactamase

EUCAST European Committee on Antimicrobial Susceptibility Testing

GSS Global *Salmonella* Surveillance

IMS Intercontinental Medical Statistics

IQR Interquartile range

ISO International Standards Organization

LFZ Laboratory for Foodborne Zoonoses

LWE Liquid whole egg

mCCDA Modified cefoperazone charcoal deoxycholate agar

MHB Mueller Hinton broth

MIC Minimum inhibitory concentration

MRSA Methicillin-resistant *Staphylococcus aureus*

MSRV Modified semi-solid Rappaport Vassiliadis

NA Not available

N/A Not applicable

NARMS National Antimicrobial Resistance Monitoring System

NC Not classified

NML National Microbiology Laboratory

OIÉ Organisation Mondiale de la Santé Animale

OR Odds ratio

PCVAD Porcine circovirus–associated disease

PHAC Public Health Agency of Canada

PPHL Provincial Public Health Laboratory

PRRS Porcine reproductive and respiratory syndrome

PT Phage type

SDCL Saskatchewan Disease Control Laboratory

STL *Salmonella* Typing Laboratory

USA United States of America

VDD Veterinary Drugs Directorate

WHO World Health Organization

Antimicrobials abbreviations

AMC Amoxicillin-clavulanic acid

AMK Amikacin

AMP Ampicillin

AZM Azithromycin

CHL Chloramphenicol

CIP Ciprofloxacin

CLI Clindamycin

CRO Ceftriaxone

DAP Daptomycin

ERY Erythromycin

FLA Flavomycin

FLR Florfenicol

FOX Cefoxitin

GEN Gentamicin

KAN Kanamycin

LIN Lincomycin

LNZ Linezolid

NAL Nalidixic acid

NIT Nitrofurantoin

PEN Penicillin

QDA Quinupristin-dalfopristin

SSS Sulfisoxazole

STR Streptomycin

SXT Trimethoprim-sulfamethoxazole

TEL Telithromycin

TET Tetracycline

TIG Tigecycline

TIO Ceftiofur

TYL Tylosin

VAN Vancomycin

Canadian provinces

AB Alberta

BC British Columbia

MB Manitoba

NB New Brunswick

NL Newfoundland and Labrador

NS Nova Scotia

NT Northwest Territories

NU Nunavut

ON Ontario

PEI Prince Edward Island

QC Québec

SK Saskatchewan

YT Yukon Territory

C.2 Glossary

Antimicrobial: Substance (including natural and synthetic products) that kills or inhibits the growth of organisms such as bacteria, fungi, viruses, or parasites. Throughout this report, the term "antimicrobial" is used to refer only to drugs effective against bacteria.

Antimicrobial resistance: Observed when the minimum inhibitory concentration of an antimicrobial is equal to or greater than the defined resistance breakpoint. Resistant bacteria are able to withstand the effects of an antimicrobial principally through 1 of these 4 mechanisms: 1) drug inactivation or modification by enzyme production, 2) adaptation of bacterial metabolism, 3) structural modification of antimicrobial targets and, 4) mechanisms to decrease drug permeability or increase drug elimination. Moreover, some bacteria have natural (or intrinsic) resistance to certain antimicrobials.

Co-resistance: Coexistence of 2 or more genes or mutations in the same bacterial strain, each of which confers resistance to a different class of drug. Also designated "associated resistance" (Aarestrup, 2006).

Cross-resistance: Situation in which resistance to 1 drug is associated with resistance to another drug, and that resistance is attributable to a single biochemical mechanism (Aarestrup, 2006). For more details, see Appendix C.3 in the 2005 CIPARS Annual Report.

Defined daily dose (DDD)**:** Statistical measure of drug consumption developed by the World Health Organization to standardize comparisons of drug usage at international and other levels, independently of cost or drug formulation.

Intermediate susceptibility: Observed when the antimicrobial MIC value is between the resistance and susceptibility breakpoints for a given bacterial isolate (reference: CLSI M100-S16).

Minimum inhibitory concentration (MIC)**:** Lowest antimicrobial concentration required to inhibit bacterial growth after an overnight in vitro incubation. The MIC is used to confirm or monitor antimicrobial resistance in bacteria. Resistance is said to exist when the MIC is higher than the defined breakpoint of resistance for a given bacterial isolate.

Multidrug resistance: Used in this report to describe resistance to more than 1 structurally-unrelated class of antimicrobials in a given bacteria isolate, regardless of the resistance mechanisms involved. Multidrug resistance (also referred to as multiple drug resistance or multiresistance) can result from bacterial mechanisms of cross-resistance and/or co-resistance. For more details, see the 2005 CIPARS Annual Report, Appendix C.3.

Reduced susceptibility: Used in this report to designate ciprofloxacin MICs from 0.125 to 2 µg/mL.

C.3 Demographic Information

Human demographic information

Table C.3.1. Population demographics and availability of health care.

Province	Post-censal population estimates 2006[a]	Post-censal population estimates 2007[a]	Percentage (%) change in 2007	Population density/km² (2007)[b]	Health care summary of discharges (2006–2007)[c]	Number of physicians in 2007[d]
Canada	**32,576,100**	**32,927,000**	**1.1**	**3.51**	**3,186,079**	**63 682**
British Columbia	4,243,600	4,310,300	1.6	4.66	745,073	8 735
Alberta	3,421,300	3,510,900	2.6	5.47	360,870	6 891
Saskatchewan	992,100	999,700	0.8	1.69	240,717	1 644
Manitoba	1,184,000	1,193,500	0.8	2.16	233,486	2 117
Ontario	12,665,300	12 793 600	1	13.94	1,091,022	22 592
Québec	7,631,600	7,686,000	0.7	5.63	NA	16 782
New Brunswick	745,700	745,400	0	10.43	151,005	1 388
Nova Scotia	938,000	936,000	-0.2	17.55	190,479	2 137
Prince Edward Island	137,900	138,100	0.1	24.40	27,762	218
Newfoundland and Labrador	510,300	506,500	-0.8	1.35	128,695	1 048
Yukon	32,300	32,600	0.9	0.07	4,920	72
Northwest Territories	43,200	43,500	0.8	0.04	9,437	49
Nunavut	30,800	31,300	1.5	0.02	2,613	9

NA = Not available.

[a] Statistics Canada. Population by year, by province and territory. Available at http://www40.statcan.ca/l01/cst01/demo02a-eng.htm. Accessed March 2009.

[b] Population density per square kilometre in 2007 was calculated on the basis of the population in 2007 and the land area in square kilometres reported by Statistics Canada at http://www40.statcan.ca/l01/cst01/phys01-eng.htm. Accessed March 2009.

[c] Canadian Institute for Health Information. *Data Quality Documentation: Discharge Abstract Database, 2006–2007*. Available at http://secure.cihi.ca/cihiweb/en/downloads/dad_dqdocumentation_executive_summary2006_2007_e.pdf. Accessed March 2009.

[d] Canadian Institute for Health Information. Health human resources – physicians. Available at: http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=statistics_results_topic_physicians_e&cw_topic=Health%20Human%20Resources&cw_subtopic=Physicians. Accessed March 2009.

Food-animal statistics

Table C.3.2. Characteristics, production, and per-capita consumption of Canadian livestock.

Farmed animal species	Number of farms in 2006	Number of animals Jan. 1, 2006	Number of animals Jan. 1, 2007	Percentage change in 2007[a]	Product produced in 2007[b] (metric tonnes)	Per-capita consumption in 2007[c,d]
Cattle	**109,901**[e]	**14,655,000**[f]	**14,155,000**[f]	**–3.41**	**1,239,750**[f]	**Beef = 30.61 kg**
Beef cows	83,000	5,247,200	5,020,100	–4.33	Calves = 38,830	Veal = 1.07 kg
Dairy cows	17,515	1,019,100	994,800	–2.38		Fluid milk = 83.21 L
Heifers (≥ 1 year old)	72,929					Cream = 8.81 L
Heifers for beef replacement	45,407	628,300	587,100	–6.56		Cheese = 12.38 kg
Heifers for dairy replacement	16,585	495,100	480,100	–3.03		
Heifers for slaughter or feeding	23,998	986,800	963,500	–2.36		
Steers (≥ 1 year old)	36,695	1,146,800	1 145 200	–0.14		
Calves (< 1 year old)	98,107	4,867,700	4,719,600	–3.04		
Bulls (≥ 1 year old)	71,958	264,000	244,600	–7.35		
Swine	**11,497**[g]	**15,110,000**[h]	**14,907,000**[h]	**–1.30**	**1,894,380**[h]	**Pork = 24.68 kg**
Sows and bred gilts	5,831	1,570,600	1,545,800	–1.60		
Boars	5,133	34,700	33,300	–4.03		
Nursing and weaner pigs	5,560					
Grower and finishing pigs	8,937					
Pigs < 20 kg		4,475,800	4,545,100	155.00		
Pigs 20–60 kg		4,623,000	4,531,700	–1.97		
Pigs > 60 kg		4,405,900	4,251,100	–3.51		
Poultry		**642,897,000**[i]	**662,098,000**[i]	**2.99**	**1,199,054**[i]	**Poultry = 37.71 kg** **Eggs = 9.89 kg**
Hens and chickens	22,712[j]	622,261,000	640,342,000	0.27	Chicken = 1,030,063	Chicken = 31.65 kg
Broilers, roasters, and cornish hens	8,831					Stewing hens = 1.57 kg
Turkeys	3,174	21,172,000	21,756,000	2.76	Turkey = 168,991	Turkey = 4.49 kg

Statistics from the 2006 CIPARS report are slightly different than those reported here. These changes were made to reflect updates in the 2007 Census of Agriculture report.

[a] Percentage change was calculated as ([2007 value – 2006 value]/2006 value) X 100.

[b] Total cold dressed weight, not including edible offal.

[c] Statistics Canada. *Food Statistics 2007*. Cat. No. 21-020-XIE. Available at http://www.statcan.gc.ca/pub/21-020-x/21-020-x2007001-eng.pdf. Accessed March 2009.

[d] Food available for consumption (eviscerated).

[e] Statistics Canada. Agriculture overview, Canada and the provinces – cattle and calves on Census Day, 2006 and 2001. Available at http://www.statcan.ca/english/freepub/95-629-XIE/1/1.24.htm. Accessed March 2009.

[f] Statistics Canada. *Cattle Statistics* 2008. Cat. No.23-012-XIE, Vol 6, No .2. Available at http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2008001.pdf. Accessed March 2009.

[g] Statistics Canada. Agriculture overview, Canada and the provinces – pigs on Census Day, 2006 and 2001. http://www.statcan.ca/english/freepub/95-629-XIE/1/1.25.htm. Accessed March 2009.

[h] Statistics Canada. Hog Statistics 2008. Cat. No. 23-010-XIE, Vol. 6, No. 3. Available at http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2008004.pdf. Accessed March 2009.

[i] Statistics Canada. *Poultry and Egg Statistics* 2008. Cat. No. 23-015-XIE, Vol. 4, No. 2. Available at http://www.statcan.gc.ca/pub/23-015-x/23-015-x2008001-eng.pdf. Accessed March 2009.

[j] Statistics Canada. Agriculture overview, Canada and the provinces – poultry inventory on Census Day, 2006 and 2001. Available at http://www.statcan.ca/english/freepub/95-629-XIE/1/1.29.htm. Accessed March 2009.

Table C.3.2. (continued). Characteristics, production, and per-capita consumption of Canadian livestock.

Farmed animal species	Number of farms in 2006	Number of animals Jan. 1, 2006	Number of animals Jan. 1, 2007	Percentage change in 2007[a]	Product produced in 2007[b] (metric tonnes)	Per-capita consumption in 2007[c,d]
Ovine	**11,031**[k]	**893,800**[l]	**879,100**[l]	**–1.64**	**17,586**[l]	**Lamb and mutton = 1.24 kg**
Ewes	10309	563,200	558,100	–0.91		
Rams	8175	25,700	26,000	1.17		
Lambs	9117					
Replacement lambs		87,100	88,200	1.26		
Market lambs		217,800	206,800	–5.05		
Fish						**Fish= 9.47 kg**
Salmons					Salmon = 117,306[m]	Fresh and frozen seafood = 4.35 kg
Trouts					Trout = 4,899	Processed seafood = 2.90 kg
Finfish					Finfish = 7,745	
Shellfish					Shellfish = 39,365	Shellfish = 1.67 kg

[a] Percentage change was calculated as ([2007 value – 2006 value]/2006 value) X 100.

[b] Total cold dressed weight, not including edible offal.

[c] Statistics Canada. *Food Statistics 2007*. Cat. No. 21-020-XIE. Available at http://www.statcan.gc.ca/pub/21-020-x/21-020-x2007001-eng.pdf. Accessed March 2009.

[d] Food available for consumption (eviscerated).

[k] Statistics Canada. Agriculture overview, Canada and the provinces – sheep and lambs on Census Day, 2006 and 2001. Available at http://www.statcan.ca/english/freepub/95-629-XIE/1/1.26.htm. Accessed March 2009.

[l] Statistics Canada. *Sheep Statistics* 2008. Cat. No. 23-011-XIE, Vol. 6, No. 2. Available at http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2008001.pdf. Accessed March 2009.

[m] Statistics Canada. *Aquaculture Statistics* 2007. Cat. No. 23-222-X. Available at http://www.statcan.ca/english/freepub/23-222-XIE/23-222-XIE2007000.pdf. Accessed March 2009.

Table C.3.3. Number of births, slaughtered animals, international imports and exports, and farm deaths of Canadian cattle, pigs, and sheep, 2007.

	Cattle[a]	Swine[b]	Sheep[c]
Births	5,541,200	34,864,000	803,500
Slaughters	2,821,400	21,265,700[d]	752,800
Percentage (%) change in slaughters in 2007[e]	–28.97	–2.40	–2.03
International imports	53,400	1,600	26,200
Percentage (%) change in imports in 2007[e]	40.53	166.00	64.78
International exports	1,411,500	10,031,600	100
Percentage (%) change in exports in 2007[e]	36.80	14.29	–96.88
Deaths and condemnations	621,700	1,263,200	130,600
Percentage (%) change in deaths and condemnations in 2007[e]	–29.43	–34.04	12.40

Statistics from the 2006 CIPARS report differ slightly from those reported here. These changes were made to reflect updates in the 2007 Census of Agriculture report.

[a] Statistics Canada. Cattle Statistics 2008. Cat. No.23-012-XIE, Vol. 6, No. 2. Available at http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2008001.pdf. Accessed March 2009.

[b] Statistics Canada. Hog Statistics 2008. Cat. No. 23-010-XIE, Vol. 6, No. 3. Available at http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2007004.pdf. Accessed March 2009.

[c] Statistics Canada. Sheep Statistics 2008. Cat. No. 23-011-XIE, Vol. 6, No. 2. Available at http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2007001.pdf. Accessed March 2009.

[d] Represents slaughter but may include pigs destined for export (varies by province).

[e] Percentage change was calculated as ([2007 value – 2006 value]/2006 value) X 100.

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