



Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

ANTIMICROBIAL RESISTANCE SHORT REPORT

2010



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

Healthy Canadians and communities in a healthier world.

Public Health Agency of Canada

Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) 2010 – Antimicrobial Resistance Short Report

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**To the memory of our dear friend and colleague,
Dr. Lucie Dutil**

"We are who we are today because of Lucie; an instrumental founding member of CIPARS. She is deeply missed and will never be forgotten."

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These acknowledgements are intended to identify and thank the numerous individuals and organizations that have contributed to the success of CIPARS 2010.

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Preamble

About CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) is pleased to present this short report on the prevalence and trends in antimicrobial resistance in selected bacterial organisms isolated from humans and the agri-food sector for the 2010 calendar year.¹ The CIPARS short reports will replace preliminary reports, as the short reports will now contain final data rather than preliminary, unless otherwise specified.

CIPARS Objectives

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

Surveillance of Human Clinical Isolates

The objective of the *Surveillance of Human Clinical Isolates* component of CIPARS is to provide a representative and methodologically unified approach to monitor temporal variations in the development of antimicrobial resistance in *Salmonella* isolated from humans at the provincial/territorial level. This component was established in 2002.

Hospital-based or private clinical laboratories 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 Public Health Laboratories (PPHLs) is voluntary and passive. A high proportion (84% in 2001)² of *Salmonella* isolates are forwarded to the PPHLs, but this proportion may vary among laboratories.

To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak-associated and non-outbreak-associated) received by the PPHLs in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador were forwarded to the National Microbiology Laboratory. The PPHLs in more populated provinces (British Columbia, Alberta, Ontario, and Québec) forwarded only the isolates received from the 1st to the 15th of each month. However, all PPHLs forwarded all human isolates of *S. Typhi* to the National Microbiology Laboratory due to the organism's clinical importance. The Yukon, Northwest Territories, and Nunavut, which do not have a PPHL counterpart, forwarded their isolates to one of the existing PPHLs. For this reason, data for the 3 territories are included in the overall number of isolates from the PPHL to which the isolates were submitted, unless the Territory was specified.

As of 2010, the antimicrobial susceptibility testing protocol of the human clinical isolates was modified and now includes testing for 7 specific *Salmonella* serovars: Heidelberg, Enteritidis, Typhimurium, I 4,[5],12:i:-, Paratyphi A, Paratyphi B, and Typhi. For the more populated provinces (British Columbia, Alberta, Ontario and Québec) only half of the Enteritidis isolates submitted during the first 15 days of the month were

¹ Any additional isolates received after completion of this short report and included in the 2010 Annual report will be highlighted.

² Report of the 2001 Canadian Laboratory Study, National Studies on Acute Gastrointestinal Illness, Division of Enteric, Foodborne and Waterborne Diseases, 2002.

tested because of the high number of isolates submitted by their PPHLs. All other *Salmonella* serovars were stored and will be available for testing in the event of any future public health concerns.

Retail Meat Surveillance (beef, chicken, and pork)

The objectives of the CIPARS *Retail Meat Surveillance* component are to provide data on antimicrobial resistance and to monitor temporal variations in resistance among selected bacteria found in raw meat at the provincial/region level. *Retail Meat Surveillance* began in 2003 in Ontario and Québec, followed by establishment of routine retail sampling activities in other provinces as resources became available (Saskatchewan in 2005, British Columbia in 2007, and the Maritimes region [New Brunswick, Nova Scotia, and Prince Edward Island] in 2008). Retail food represents a logical sampling point for surveillance of antimicrobial resistance because it is the endpoint of food animal production, and thus is indicative of human exposure. Retail surveillance provides a measure of human exposure to antimicrobial-resistant bacteria through consumption of meat products from selected commodities. The scope of the surveillance framework can be modified (e.g. food commodities, bacteria, or geographic region) as necessary and functions as a research platform for investigation of specific questions regarding antimicrobial resistance in the agri-food sector.

The commodities of interest for this component were raw meat products most commonly consumed by Canadians. These commodities and the products sampled included poultry (chicken legs or wings [skin on]), pork (chops), and beef (ground beef). The unit of analysis in *Retail Meat Surveillance* was bacterial isolate recovered from raw meat. Bacteria of interest in chicken were *Campylobacter*, *Salmonella*, and generic *Escherichia coli*. As of January 1, 2010, no attempt has been made to isolate *Enterococcus* from retail-level chicken samples as no vancomycin-resistant enterococci, which are strains of particular public health concern, have been detected in retail isolates since CIPARS began. From beef and pork, only *E. coli* was 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 phases of the program. *Salmonella* was isolated from pork, primarily to provide recovery estimates for this commodity for other Public Health Agency of Canada programs. These *Salmonella* strains were also submitted for antimicrobial susceptibility testing; however, given the low numbers recovered annually, results are not presented on an annual basis. Instead, those results have been pooled and are presented over a multi-year period in the interest of precision.

The sampling protocol 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/region. In 2010, retail meat samples were collected weekly in Ontario and Québec and bi-weekly in British Columbia, Saskatchewan, and the Maritimes region. Prevalence estimates were used to determine the number of samples to be collected, which was based on an expected yield of 100 isolates per commodity per province/region per year plus 20% to account for lost or damaged samples. Because sampling was less frequent in British Columbia, Saskatchewan, and the Maritimes region relative to sampling in Ontario and Québec, the target of 100 isolates per year may not have always been achieved in those provinces/region.

Abattoir Surveillance (beef cattle, chickens, and pigs)

The objectives of the CIPARS *Abattoir Surveillance* component are to provide nationally representative, annual antimicrobial resistance data for bacteria isolated from animals entering the food supply and to monitor temporal variations in the prevalence of antimicrobial resistance in these bacteria. *Abattoir Surveillance* includes only animals that originated from premises within Canada.

For this component, the unit of analysis was the bacterial isolate, each of which was cultured from the caecal contents (not carcasses) of slaughtered food animals. Caecal contents were used to avoid misinterpretation related to cross-contamination and to better reflect antimicrobial resistance in bacteria that originated from the farm. Established in September 2002, this component initially targeted generic *Escherichia coli* and *Salmonella* from the meat commodities with the highest per capita consumption: beef cattle, broiler chickens, and pigs. In 2003, the component was refined to discontinue *Salmonella* isolation

from beef cattle because of the low prevalence of *Salmonella* in that population. *Campylobacter* surveillance was initiated in beef cattle in late 2005 to include a human pathogen in beef cattle surveillance and, following the approval of a fluoroquinolone for use in cattle, to provide information on fluoroquinolone resistance. *Campylobacter* surveillance was initiated in broiler chicken in 2010 out of concern about fluoroquinolone and ceftiofur resistance in isolates previously recovered from chicken through CIPARS *Retail Meat Surveillance*. The sampling method was designed with the goal that, across Canada, 100 isolates of *Campylobacter* and 150 isolates each of *Salmonella* and *E. coli* would be recovered from each animal species over a 12-month period to avoid any potential seasonal bias in bacteria prevalence and antimicrobial susceptibility.

Over 90% of all food-producing animals in Canada are slaughtered in federally inspected abattoirs annually. Forty federally inspected slaughter plants (5 beef cattle plants, 23 poultry plants, and 12 swine plants) from across Canada participated in 2010.

Farm Surveillance (pigs)

The objectives of the CIPARS *Farm Surveillance* component are to provide data on antimicrobial use and resistance, monitor temporal variations in the development of antimicrobial resistance, investigate associations between antimicrobial use and resistance in isolates from swine farms, and provide data for human-health risk assessments.

This initiative is based on a sentinel farm framework that provides herd-level data on antimicrobial use and pooled fecal samples collected from pens of grower-finisher pigs for bacterial isolation and antimicrobial susceptibility testing. For this component, the unit of analysis for the antimicrobial resistance data was the bacterial isolate. These data were adjusted for clustering at the herd-level. The bacteria of interest were *Salmonella*, generic *Escherichia coli*, and *Enterococcus*.

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 had been extensively implemented by the industry, there had not been a recent outbreak of foreign animal disease in pigs, and there was a similar initiative in swine in the United States (Collaboration in Animal Health and Food Safety Epidemiology).

In 2010, 22 swine veterinarians enrolled 91 client producers with CQA® validated operations that produced more than 2,000 market pigs per year, and were representative of the demographic and geographic distribution of herds in the veterinarian's swine practice. Criteria for exclusion were as follows: herds regarded as organically raised, herds in which edible residual material was fed, or herds that were raised on pasture. These criteria helped ensure that the herds enrolled were representative of the majority of swine operations in Canada. In each of the participating provinces, the number of CIPARS sentinel sites was proportional to the national total of grower-finisher units. An exception was Alberta, where additional herds were enrolled with provincial support.

Surveillance of Animal Clinical Isolates (cattle, chickens, pigs, turkeys, and horses)

The objective of the CIPARS *Surveillance of Animal Clinical Isolates* component is to detect new and/or emerging antimicrobial resistance patterns or new serovar/resistance pattern combinations in *Salmonella*. This component of CIPARS is based on submissions from veterinarians and/or producers to veterinary diagnostic laboratories. Sample collection and submission practices, as well as *Salmonella* isolation protocols, vary among laboratories.

Salmonella isolates were sent by private veterinary and provincial animal health laboratories from across the country to the *Salmonella* Typing Laboratory at the Laboratory for Foodborne Zoonoses (LFZ), Guelph, Ontario. An exception was Québec, where isolates from animal health laboratories were sent to the Direction des laboratoires d'expertises du Ministère de l'Agriculture, des Pêcheries et de l'Alimentation

du Québec, Saint-Hyacinthe for serotyping. Isolates and serotyping results from Québec were then forwarded to the LFZ to undergo phage typing and antimicrobial resistance testing.

Unlike the *Surveillance of Human Clinical Isolates* component, the proportion of *Salmonella* isolates forwarded to the LFZ from private and provincial animal health laboratories was not determined by a national sampling scheme and therefore varied within and between provinces. As well, isolates were not solely of clinical origin; some may also have been collected from animal feed, the animal's environment, or non-diseased animals from the same herd. The results for cattle, chickens, pigs, turkeys, and horses are reported in this report. Cattle isolates could have originated from dairy cattle, milk-fed or grain-fed veal, or beef cattle. Chicken isolates were largely from layer hens and broiler chickens, but may have originated from primary layer breeders or broiler breeder birds as well.

Feed and Feed Ingredients

Data from the *Feed and Feed Ingredients* component of CIPARS were obtained from various sources, including monitoring programs of the CFIA and a few isolates from provincial authorities. Information on specimen collection methods was only available for the CFIA monitoring programs.

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 mashes. 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* serovar that is highly pathogenic (e.g. Typhimurium, Enteritidis, or Newport). Program 15E is a targeted program; samples are not randomly selected.

What's New in the 2010 Report

Changes to CIPARS Antimicrobial Resistance Surveillance Component

- The antimicrobial susceptibility testing protocol of the human clinical isolates was modified and now focuses on 7 *Salmonella* serovars: Heidelberg, Enteritidis, Typhimurium, I 4,[5],12:i:-, Paratyphi A, Paratyphi B, and Typhi.
- Bacterial culture and antimicrobial susceptibility testing of *Enterococcus* isolates from retail chicken meat was discontinued as of January 1, 2010. Antimicrobial resistance surveillance of this bacterial species at the retail level may be reintroduced at a later date.
- Bacterial culture and antimicrobial susceptibility testing of *Campylobacter* isolates from abattoir chickens was initiated in January 2010.

Methodological Changes

- A molecular method (genus- and species-specific Multiplex PCR) was used in replacement of the standard method (biochemical tests) for all *Campylobacter* isolates to perform identification and speciation.
- Half of the *Salmonella* Enteritidis human clinical isolates submitted by the most populated provinces (British Columbia, Alberta, Ontario, and Québec) during the first 15 days of the month

were tested due to the high number of isolates submitted by their provincial public health laboratories.

Important Notes

Antimicrobial Groupings

- Category of importance in human medicine: Antimicrobials were categorized on the basis of importance in human medicine (Veterinary Drugs Directorate, Health Canada; categories revised in April 2009).¹

Additional Notes

- Additional animal clinical isolates might be tested after the publication of this report. In this case, updated results will be presented in the 2010 Annual Report.
- *Surveillance of Animal Clinical Isolates* and antimicrobial resistance figures: Confidence intervals are not displayed for this component because samples are not obtained randomly and may not represent independent observations. Therefore, the results may not reflect true prevalence of antimicrobial resistance, but can be used to highlight the occurrence of emerging or re-emerging resistance.

¹ http://www.hc-sc.gc.ca/dhp-mps/consultation/vet/consultations/amr_ram_hum-med-rev-eng.php

Antimicrobial Resistance

Humans

Salmonella (n = 2,294)

Salmonella Enteritidis

(n = 996)

Table 1. Resistance to antimicrobials in *Salmonella* Enteritidis isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada ^a
	BC n = 135	AB n = 110	SK n = 61	MB n = 98	ON n = 293	QC n = 112	NB n = 70	NS n = 75	PEI n = 19	NL n = 23	
I Amoxicillin-clavulanic acid	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
I Cefotiofur	0 (0)	1 (1)	0 (0)	1 (1)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
I Ceftriaxone	0 (0)	1 (1)	0 (0)	1 (1)	0 (0)	2 (2)	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 (3)	1 (2)	3 (3)	5 (2)	2 (2)	1 (1)	2 (3)	1 (5)	1 (4)	2
II Cefoxitin	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	2 (3)	0 (0)	0 (0)	0 (0)	< 1
II Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	< 1
II Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	< 1
II Nalidixic acid	9 (7)	9 (8)	4 (7)	2 (2)	38 (13)	25 (22)	5 (7)	8 (11)	1 (5)	2 (9)	12
II Streptomycin	2 (1)	1 (1)	0 (0)	3 (3)	3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
II Trimethoprim-sulfamethoxazole	2 (1)	0 (0)	1 (2)	1 (1)	6 (2)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1
III Chloramphenicol	0 (0)	1 (1)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
III Sulfisoxazole	4 (3)	2 (2)	1 (2)	3 (3)	8 (3)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	2
III Tetracycline	6 (4)	3 (3)	1 (2)	3 (3)	7 (2)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	3
IV											

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

Provincial abbreviations are defined in the Appendix.

^a Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces. For BC, AB, ON and QC only half of the *S. Enteritidis* isolates submitted during the first 15 days of the month were tested due to the high number of isolates submitted by their provincial public health laboratories.

Salmonella Heidelberg

(n = 476)

Table 2. Resistance to antimicrobials in *Salmonella* Heidelberg isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada ^a
	BC n = 31	AB n = 73	SK n = 10	MB n = 25	ON n = 157	QC n = 129	NB n = 28	NS n = 14	PEI n = 6	NL n = 3	%
I Amoxicillin-clavulanic acid	15 (48)	5 (7)	1 (10)	5 (20)	32 (20)	27 (21)	2 (7)	2 (14)	0 (0)	0 (0)	19
Ceftiofur	16 (52)	5 (7)	1 (10)	5 (20)	32 (20)	27 (21)	2 (7)	2 (14)	0 (0)	0 (0)	20
Ceftriaxone	16 (52)	6 (8)	1 (10)	5 (20)	32 (20)	27 (21)	2 (7)	2 (14)	0 (0)	0 (0)	20
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
Ampicillin	17 (55)	11 (15)	1 (10)	6 (24)	53 (34)	50 (39)	7 (25)	4 (29)	1 (17)	1 (33)	33
Cefoxitin	15 (48)	5 (7)	1 (10)	5 (20)	32 (20)	27 (21)	2 (7)	2 (14)	0 (0)	0 (0)	19
Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	2 (2)	1 (4)	2 (14)	0 (0)	0 (0)	1
Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	4 (3)	0 (0)	1 (4)	2 (14)	0 (0)	0 (0)	1
Nalidixic acid	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
Streptomycin	0 (0)	1 (1)	0 (0)	0 (0)	12 (8)	8 (6)	4 (14)	2 (14)	0 (0)	0 (0)	6
Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
III Chloramphenicol	0 (0)	0 (0)	0 (0)	0 (0)	3 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
Sulfisoxazole	0 (0)	2 (3)	0 (0)	0 (0)	6 (4)	3 (2)	1 (4)	2 (14)	0 (0)	0 (0)	3
Tetracycline	2 (6)	4 (5)	0 (0)	0 (0)	4 (3)	2 (2)	1 (4)	3 (21)	0 (0)	0 (0)	3
IV											

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

Provincial abbreviations are defined in the Appendix.

^a Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces (see Appendix A of the 2008 CIPARS Annual Report).

Salmonella I 4,[5],12:i:-

(n = 163)

Table 3. Resistance to antimicrobials in *Salmonella* I 4,[5],12:i:- isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada ^a
	BC n = 16	AB n = 35	SK n = 15	MB n = 22	ON n = 29	QC n = 34	NB n = 8	NS n = 2	PEI n = 1	NL n = 1	%
I Amoxicillin-clavulanic acid	2 (13)	3 (9)	0 (0)	2 (9)	3 (10)	1 (3)	1 (13)	0 (0)	0 (0)	1 (100)	8
Ceftiofur	2 (13)	3 (9)	0 (0)	2 (9)	4 (14)	1 (3)	1 (13)	0 (0)	0 (0)	1 (100)	9
Ceftriaxone	2 (13)	3 (9)	0 (0)	2 (9)	4 (14)	1 (3)	1 (13)	0 (0)	0 (0)	1 (100)	9
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
Ampicillin	6 (38)	6 (17)	0 (0)	8 (36)	10 (34)	24 (71)	2 (25)	0 (0)	0 (0)	1 (100)	37
Cefoxitin	2 (13)	3 (9)	0 (0)	2 (9)	3 (10)	1 (3)	1 (13)	0 (0)	0 (0)	1 (100)	8
Gentamicin	0 (0)	1 (3)	0 (0)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	1 (3)	6 (18)	0 (0)	0 (0)	0 (0)	0 (0)	5
Nalidixic acid	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	< 1
Streptomycin	6 (38)	2 (6)	0 (0)	6 (27)	7 (24)	24 (71)	1 (13)	0 (0)	0 (0)	0 (0)	31
Trimethoprim-sulfamethoxazole	1 (6)	0 (0)	0 (0)	0 (0)	1 (3)	2 (6)	0 (0)	0 (0)	0 (0)	0 (0)	3
III Chloramphenicol	2 (13)	0 (0)	0 (0)	0 (0)	3 (10)	4 (12)	0 (0)	0 (0)	0 (0)	0 (0)	6
Sulfisoxazole	6 (38)	2 (6)	0 (0)	0 (0)	7 (24)	25 (74)	1 (13)	0 (0)	0 (0)	0 (0)	29
Tetracycline	8 (50)	17 (49)	6 (40)	4 (18)	6 (21)	23 (68)	1 (13)	0 (0)	0 (0)	0 (0)	43
IV											

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

Provincial abbreviations are defined in the Appendix.

^a Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces (see Appendix A of the 2008 CIPARS Annual Report).

Salmonella Paratyphi A and Paratyphi B

(n = 30)

Table 4. Resistance to antimicrobials in *Salmonella* Paratyphi A and Paratyphi B isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada ^a
	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	
	n = 2	n = 2	n = 1	n = 0	n = 18	n = 5	n = 0	n = 2	n = 0	n = 0	
											%
I Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Ceftiofur	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Ceftriaxone	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Ciprofloxacin	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		1 (50)			2
II Amikacin	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Ampicillin	1 (50)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			4
Cefoxitin	0 (0)	0 (0)	0 (0)		1 (6)	0 (0)		0 (0)			4
Gentamicin	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Kanamycin	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
Nalidixic acid	1 (50)	2 (100)	0 (0)		8 (44)	1 (20)		1 (50)			44
Streptomycin	1 (50)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			4
Trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			0
III Chloramphenicol	1 (50)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			4
Sulfisoxazole	1 (50)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			4
Tetracycline	1 (50)	0 (0)	0 (0)		0 (0)	0 (0)		0 (0)			4
IV											

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Provincial abbreviations are defined in the Appendix.

Salmonella Paratyphi B 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 severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate+ is commonly associated with gastrointestinal illness.

No *S. Paratyphi* A or *S. Paratyphi* B isolates were received from Manitoba, New Brunswick, Prince Edward Island or Newfoundland and Labrador.

^a Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces (see Appendix A of the 2008 CIPARS Annual Report).

Salmonella Typhi

(n = 178)

Table 5. Resistance to antimicrobials in *Salmonella Typhi* isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada %
	BC n = 33	AB n = 19	SK n = 2	MB n = 13	ON n = 91	QC n = 18	NB n = 0	NS n = 1	PEI n = 1	NL n = 0	
I Amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)	1 (6)		0 (0)	0 (0)		4
II Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Ampicillin	5 (15)	4 (21)	0 (0)	3 (23)	15 (16)	1 (6)		0 (0)	0 (0)		16
Cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Kanamycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)		0
Nalidixic acid	29 (88)	18 (95)	2 (100)	12 (92)	80 (88)	12 (67)		1 (100)	1 (100)		87
Streptomycin	5 (15)	4 (21)	0 (0)	3 (23)	14 (15)	1 (6)		0 (0)	0 (0)		15
Trimethoprim-sulfamethoxazole	5 (15)	4 (21)	0 (0)	3 (23)	17 (19)	1 (6)		0 (0)	0 (0)		17
III Chloramphenicol	5 (15)	4 (21)	0 (0)	3 (23)	17 (19)	1 (6)		0 (0)	0 (0)		17
Sulfisoxazole	5 (15)	4 (21)	0 (0)	3 (23)	17 (19)	1 (6)		0 (0)	0 (0)		17
Tetracycline	0 (0)	0 (0)	0 (0)	3 (23)	1 (1)	0 (0)		0 (0)	0 (0)		1
IV											

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

Provincial abbreviations are defined in the Appendix.

No *S. Typhi* isolates were received from New Brunswick and Newfoundland and Labrador.

Salmonella Typhimurium

(n = 451)

Table 6. Resistance to antimicrobials in *Salmonella Typhimurium* isolates; Surveillance of Human Clinical Isolates, 2010.

Antimicrobial	Number (%) of isolates resistant										Canada ^a %
	BC n = 35	AB n = 48	SK n = 54	MB n = 15	ON n = 189	QC n = 73	NB n = 15	NS n = 17	PEI n = 0	NL n = 5	
I Amoxicillin-clavulanic acid	0 (0)	1 (2)	0 (0)	0 (0)	4 (2)	3 (4)	0 (0)	0 (0)		0 (0)	2
Ceftiofur	0 (0)	1 (2)	0 (0)	0 (0)	3 (2)	2 (3)	0 (0)	0 (0)		0 (0)	2
Ceftriaxone	0 (0)	1 (2)	0 (0)	0 (0)	3 (2)	2 (3)	0 (0)	0 (0)		0 (0)	2
Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0
II Amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)	0
Ampicillin	11 (31)	20 (42)	5 (9)	4 (27)	47 (25)	15 (21)	3 (20)	3 (18)		1 (20)	25
Cefoxitin	0 (0)	1 (2)	0 (0)	0 (0)	3 (2)	2 (3)	0 (0)	0 (0)		0 (0)	2
Gentamicin	1 (3)	0 (0)	0 (0)	0 (0)	2 (1)	2 (3)	1 (7)	0 (0)		0 (0)	1
Kanamycin	6 (17)	13 (27)	0 (0)	4 (27)	17 (9)	8 (11)	1 (7)	1 (6)		0 (0)	12
Nalidixic acid	0 (0)	2 (4)	1 (2)	0 (0)	5 (3)	2 (3)	1 (7)	0 (0)		0 (0)	3
Streptomycin	12 (34)	17 (35)	5 (9)	1 (7)	52 (28)	22 (30)	1 (7)	3 (18)		0 (0)	27
Trimethoprim-sulfamethoxazole	2 (6)	2 (4)	1 (2)	0 (0)	5 (3)	6 (8)	1 (7)	0 (0)		0 (0)	4
III Chloramphenicol	7 (20)	8 (17)	3 (6)	0 (0)	45 (24)	12 (16)	1 (7)	3 (18)		0 (0)	19
Sulfisoxazole	13 (37)	22 (46)	4 (7)	4 (27)	54 (29)	23 (32)	2 (13)	3 (18)		0 (0)	30
Tetracycline	11 (31)	18 (38)	5 (9)	4 (27)	50 (26)	19 (26)	2 (13)	4 (24)		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.

Provincial abbreviations are defined in the Appendix.

No *S. Typhimurium* isolates were received from Prince Edward Island.

^a Estimated percentages for Canada have been corrected for non-proportional submission protocols among provinces (see Appendix A of the 2008 CIPARS Annual Report).

Table 7. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates; Surveillance of Human Clinical Isolates, 2010.

Province / serovar	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																					
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides					β-lactams					Folate pathway inhibitors		Phenicol		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET		
British Columbia																							
Enteritidis	135 (53.6)	122	8	2	3				2	4					4	2				9	6		
Typhimurium	35 (13.9)	22		2	11	1	6	12	11						13	2	7				11		
Typhi	33 (13.1)	4	24		5			5	5						5	5	5			29			
Heidelberg	31 (12.3)	14	15	2					17	15	16	15	16								2		
I 4,[5],12:i:-	16 (6.3)	6	4	1	5			6	6	2	2	2	2	2	6	1	2				8		
Paratyphi A and B	2 (0.8)		1		1			1	1						1		1			1	1		
Total	252 (100)	168	52	7	25	1	6	26	44	17	18	17	18	29	10	15			39	28			
Alberta																							
Enteritidis	110 (38.3)	98	9	1	2			1	3	1	1	1	1	2			1			9	3		
Heidelberg	73 (25.4)	61	6	6				1	11	5	6	5	5	2							4		
Typhimurium	48 (16.7)	23	2	5	18			13	17	20	1	1	1	1	22	2	8			2	18		
I 4,[5],12:i:-	35 (12.2)	15	17	1	2	1		2	6	3	3	3	3	2						1	17		
Typhi	19 (6.6)	1	14		4			4	4						4	4	4			18			
Paratyphi A and B	2 (0.7)		2																	2			
Total	287 (100)	198	50	13	26	1	13	25	44	10	11	10	10	32	6	13			32	42			
Saskatchewan																							
Enteritidis	61 (42.7)	55	5	1						1					1	1				4	1		
Typhimurium	54 (37.8)	48		1	5			5	5						4	1	3			1	5		
I 4,[5],12:i:-	15 (10.5)	9	6																		6		
Heidelberg	10 (7.0)	9	1						1	1	1	1	1										
Typhi	2 (1.4)		2																	2			
Paratyphi A and B	1 (0.7)	1																					
Total	143 (100)	122	14	2	5			5	7	1	1	1	1	5	2	3			7	12			
Manitoba																							
Enteritidis	98 (56.6)	93	1	2	2			3	3		1		1	3	1					2	3		
Heidelberg	25 (14.5)	19	6						6	5	5	5	5										
I 4,[5],12:i:-	22 (12.7)	10	6	6				6	8	2	2	2	2								4		
Typhimurium	15 (8.7)	11			4			4	1	4					4						4		
Typhi	13 (7.5)	1	9		3			3	3					3	3	3				12	3		
Total	173 (100)	134	22	8	6	3		4	13	24	7	8	7	8	10	4	3		14	14			
Ontario																							
Enteritidis	293 (37.7)	246	39	5	3			3	5					8	6	2				38	7		
Typhimurium	189 (24.3)	128	5	11	41	4		2	17	52	47	4	3	3	3	3	54	5	45	5	50		
Heidelberg	157 (20.2)	95	51	10	1			2	4	12	53	32	32	32	32	6	2	3		1	4		
Typhi	91 (11.7)	11	62	4	13	1			14	15					17	17	17		5	80	1		
I 4,[5],12:i:-	29 (3.7)	18	4	1	6			1	1	7	10	3	4	3	4	7	1	3			6		
Paratyphi A and B	18 (2.3)	10	7	1										1						8			
Total	777 (100)	508	168	32	64	5		5	22	88	130	39	39	39	39	92	31	70	5	132	68		
Québec																							
Heidelberg	129 (35.1)	77	42	10				2	8	50	27	27	27	27	3						2		
Enteritidis	112 (30.4)	85	25	2						2	2	2	1	2	1	1				25	2		
Typhimurium	73 (19.8)	45	3	11	14			2	8	22	15	3	2	2	2	23	6	12		2	19		
I 4,[5],12:i:-	31 (8.4)	7	2	3	19			6	21	21	1	1	1	1	22	2	4				20		
Typhi	18 (4.9)	6	11	1					1	1					1	1	1		1	12			
Paratyphi A and B	5 (1.4)	4	1																	1			
Total	368 (100)	224	84	26	34			4	14	52	89	33	32	31	32	50	10	17	1	40	43		
New Brunswick																							
Enteritidis	70 (57.9)	62	8							1			2							5			
Heidelberg	28 (23.1)	20	3	5				1	1	4	7	2	2	2	2	1					1		
Typhimurium	15 (12.4)	12		1	2			1	1	1	3				2	1	1			1	2		
I 4,[5],12:i:-	8 (6.6)	6	1		1				1	2	1	1	1	1	1						1		
Total	121 (100)	100	12	6	3			2	2	6	13	3	3	5	3	4	1	1		6	4		
Nova Scotia																							
Enteritidis	75 (67.6)	65	10							2										8			
Typhimurium	17 (15.3)	13		1	3			1	3	3					3		3				4		
Heidelberg	14 (12.6)	8	3	3				2	2	2	4	2	2	2	2	2					3		
I 4,[5],12:i:-	2 (1.8)	2																					
Paratyphi A and B	2 (1.8)	1	1																	1	1		
Typhi	1 (0.9)		1																		1		
Total	111 (100)	89	15	4	3			2	3	5	9	2	2	2	2	5	3	1	10	7			

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Salmonella Paratyphi B 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 severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate+ is commonly associated with gastrointestinal illness.

Table 7 (continued). Number of antimicrobial classes in resistance patterns of *Salmonella* isolates; Surveillance of Human Clinical Isolates, 2010.

Province / serovar	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																			
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides				β-lactams				Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET
Prince Edward Island																					
Enteritidis	19 (70.4)	17	2							1										1	
Heidelberg	6 (22.2)	5	1							1											
I 4,[5],12:i-	1 (3.7)	1																			
Typhi	1 (3.7)	1																			1
Total	27 (100)	23	4							2										2	
Newfoundland and Labrador																					
Enteritidis	23 (71.9)	21	1	1		1	1			1											2
Typhimurium	5 (15.6)	4	1							1											
Heidelberg	3 (9.4)	2	1							1											
I 4,[5],12:i-	1 (3.1)	1								1	1	1	1	1							
Total	32 (100)	27	4	1		1	1			4	1	1	1	1						2	

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Figure 1. Temporal variation in resistance to selected antimicrobials in human isolates of *Salmonella* serovars Enteritidis, Heidelberg, and I 4,[5],12:i:-; *Surveillance of Human Clinical Isolates, 2003–2010.*

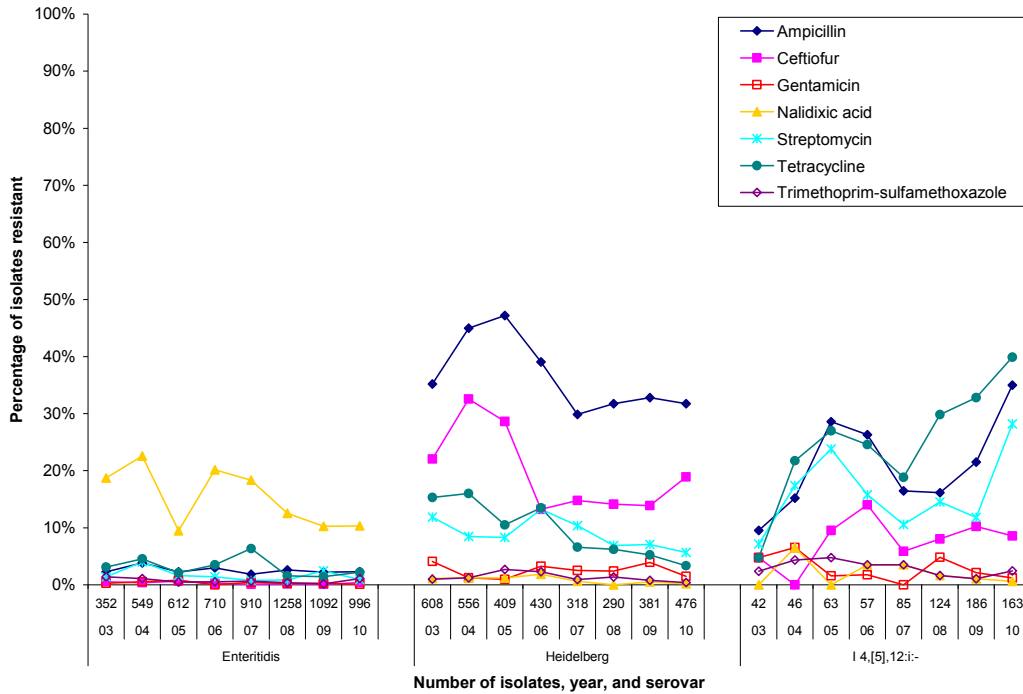
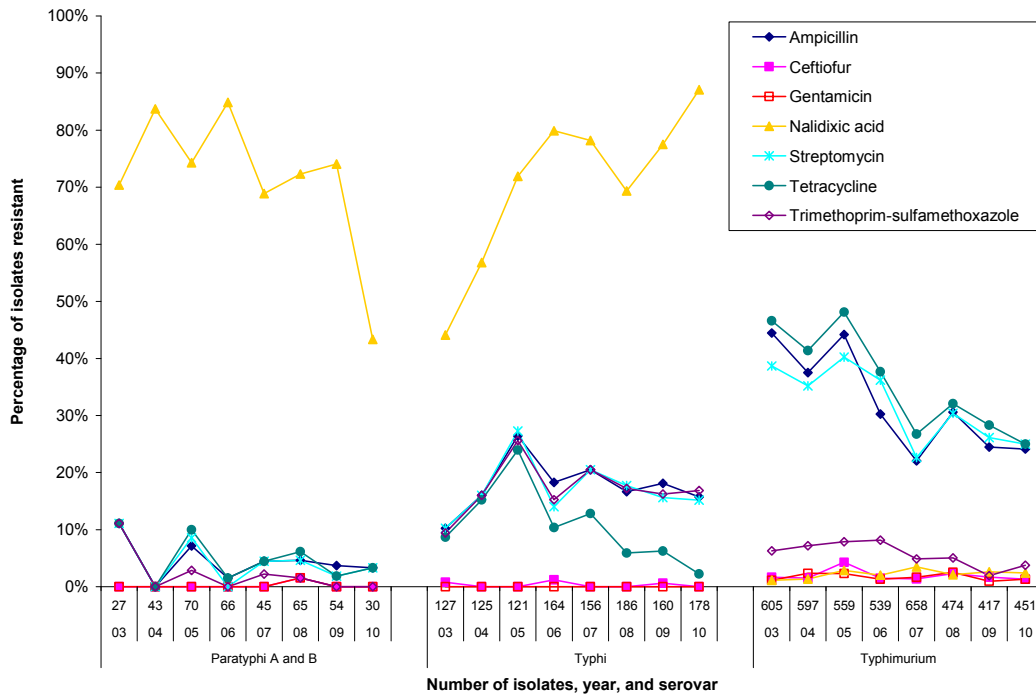


Figure 2. Temporal variation in resistance to selected antimicrobials in human isolates of *Salmonella* serovars Paratyphi A and Paratyphi B, Typhi, and Typhimurium; *Surveillance of Human Clinical Isolates, 2003–2010.*



Salmonella Paratyphi B 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 gastrointestinal illness.

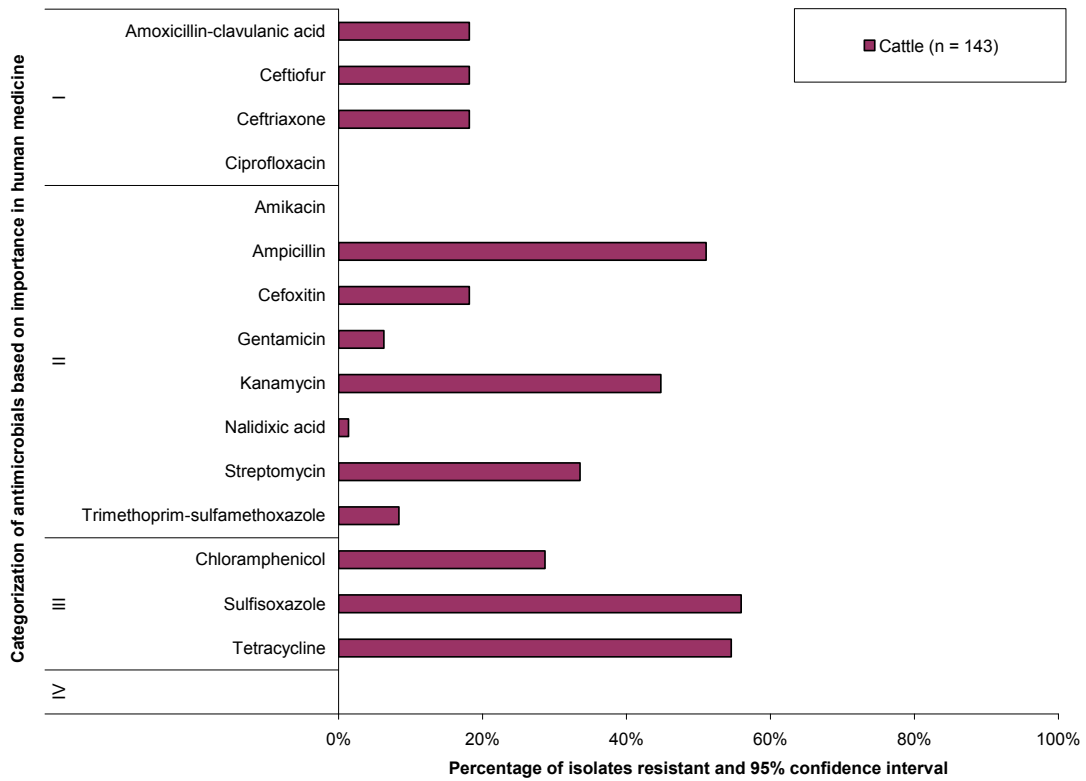
Beef Cattle

Salmonella

Surveillance of Animal Clinical Isolates

(n = 143)

Figure 3. Resistance to antimicrobials in *Salmonella* isolates from cattle; *Surveillance of Animal Clinical Isolates*, 2010.



Confidence intervals are not displayed for animal clinical data because samples were not obtained randomly and may not represent independent observations.

Table 8. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from cattle; Surveillance of Animal Clinical Isolates, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial															
		0	1	2-3	4-5	6	Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
							AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET	
Typhimurium var. 5-	48 (33.6)	2	1	45			45	22	45	15	15	15	15	46	1	15					46	
Typhimurium	39 (27.3)	20	2	17			10	17	15	2	2	2	2	19	8	16			2	18		
Enteritidis	10 (7)	10																				
Dublin	6 (4.2)			6			6	6	1	6	6	6	6	6		6					6	
Heidelberg	5 (3.5)	5																				
I 4,[5],12:i:-	5 (3.5)	2		3			2	3	3	1	1	1	1	3	1	3					3	
Infantis	4 (2.8)	4																				
Mbandaka	4 (2.8)	2	2					2						2							2	
Muenster	3 (2.1)	3																				
Less common serovars	19 (13.3)	14	2	3			3	1	3	4	2	2	2	4	2	1					3	
Total	143 (100)	62	2	5	74		9	64	48	73	26	26	26	26	80	12	41		2	78		

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

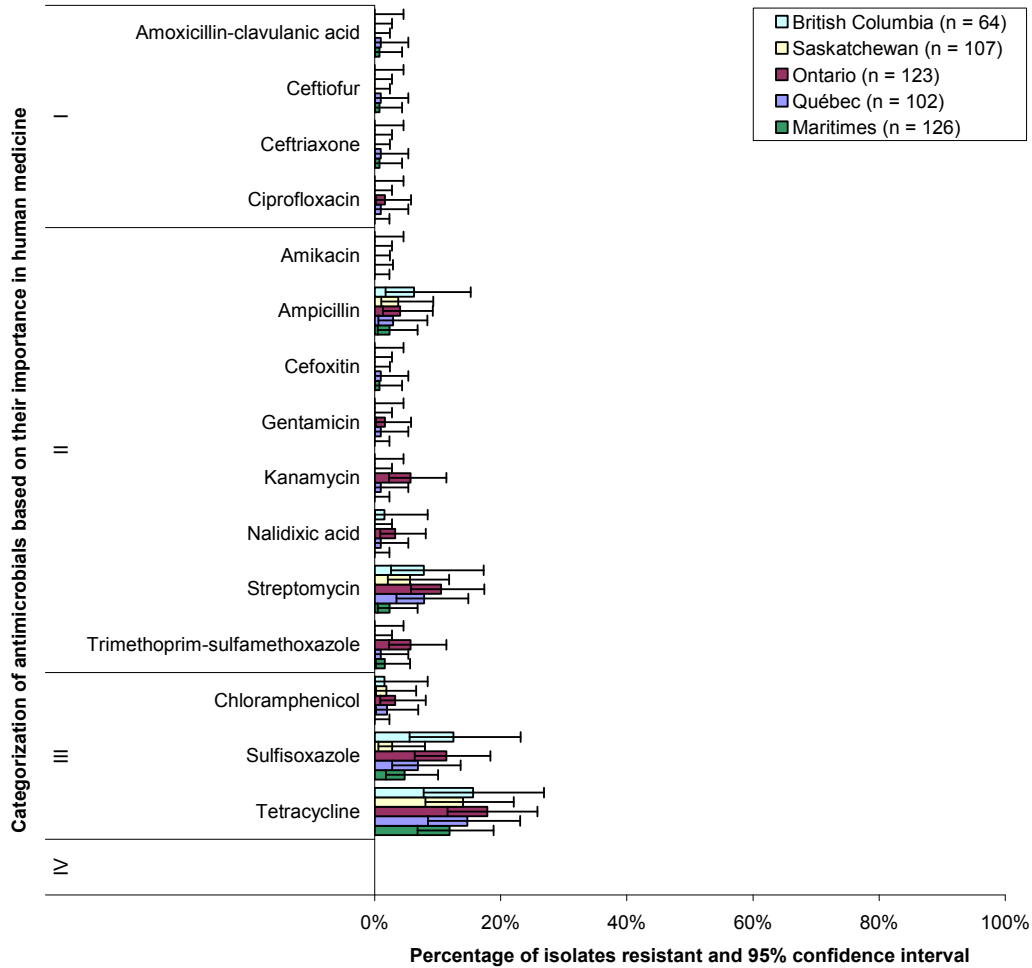
Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Escherichia coli

Retail Meat Surveillance

(n = 522)

Figure 4. Resistance to antimicrobials in *Escherichia coli* isolates from beef; Retail Meat Surveillance, 2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

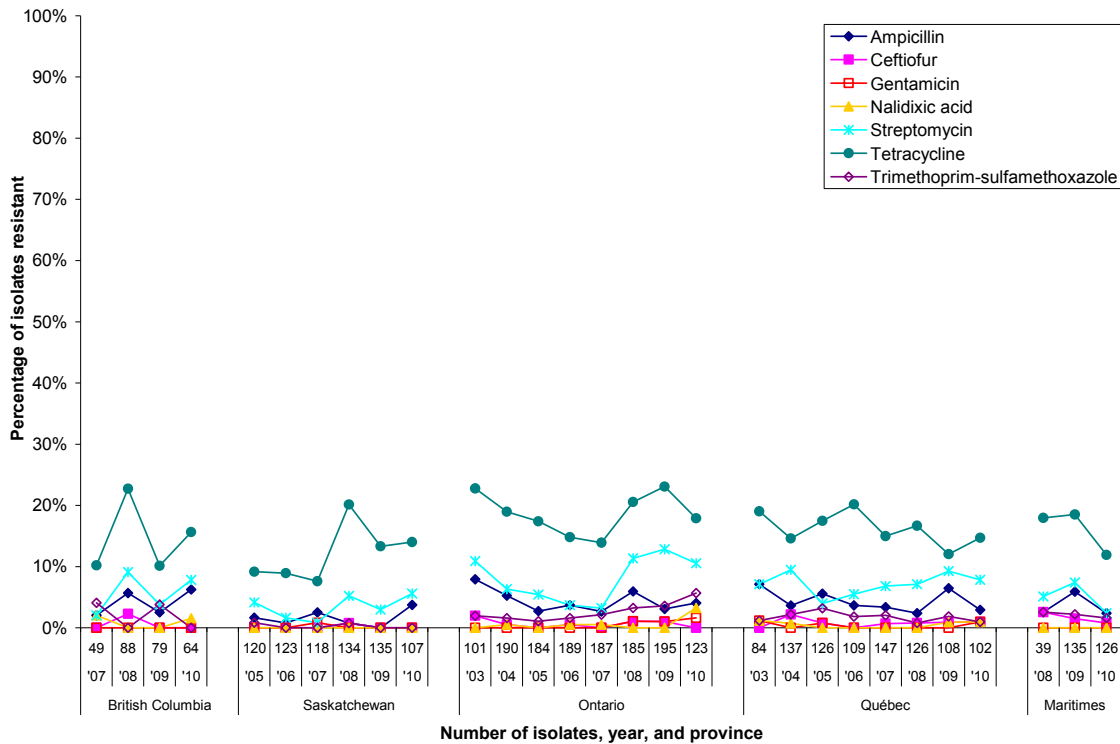
Table 9. Number of antimicrobial classes in resistance patterns of *Escherichia coli* isolates from beef; Retail Meat Surveillance, 2010.

Province	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																										
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides										β-lactams					Folate pathway inhibitors		Phenicolis		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET							
British Columbia	64 (12.3)	53	2	6	3				5	4					8		1		1		10							
Saskatchewan	107 (20.5)	92	7	6	2				6	4					3		2				15							
Ontario	123 (23.6)	100	6	12	3	2	2	7	13	5					14	7	4	2	4		22							
Québec	102 (19.5)	85	5	11	1		1	1	8	3	1	1	1	1	7	1	2	1	1		15							
Maritimes	126 (24.1)	111	7	7	1				3	3	1	1	1	1	6	2					15							

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Figure 5. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef; Retail Meat Surveillance, 2003–2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Abattoir Surveillance

(n = 77)¹

Figure 6. Resistance to antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance*, 2010.

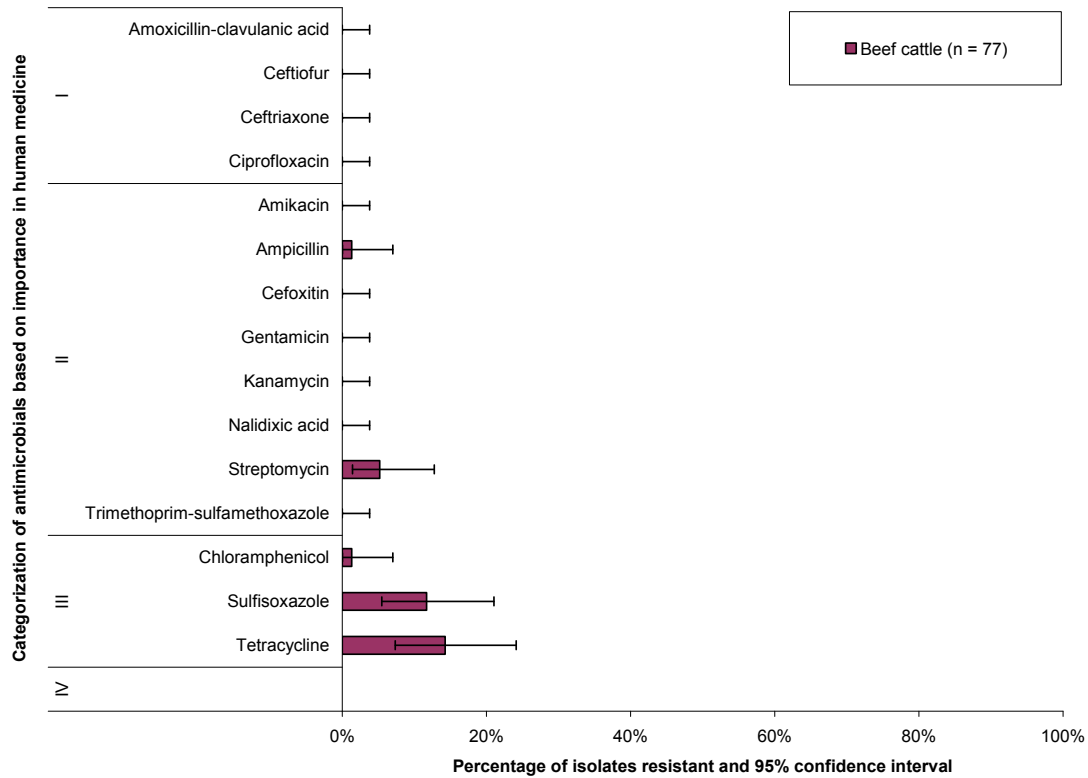


Table 10. Number of antimicrobial classes in resistance patterns of *Escherichia coli* isolates from beef cattle, chickens, or pigs; *Abattoir Surveillance*, 2010.

Species	Number of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																		
		Number of isolates by number of antimicrobial classes in the resistance pattern				Aminoglycosides		β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines	
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL
Beef cattle	77	65	2	9	1				4	1					9		1			11
Chickens	119	24	21	53	21	12	18	59	63	46	45	47	41	47	12		10		5	62
Pigs	199	34	36	88	41	30	71	73	4	4	4	4	4	92	28	36				143

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

¹ In 2010, the number of samples received from abattoir beef cattle was much lower than anticipated due to a 55% drop in submissions related to unavoidable operational issues at 2 major participating abattoirs.

Figure 7. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from beef cattle; *Abattoir Surveillance, 2003–2010*.



Campylobacter

Abattoir Surveillance

(n = 37)¹

Figure 8. Resistance to antimicrobials in *Campylobacter* isolates from beef cattle; *Abattoir Surveillance*, 2010.

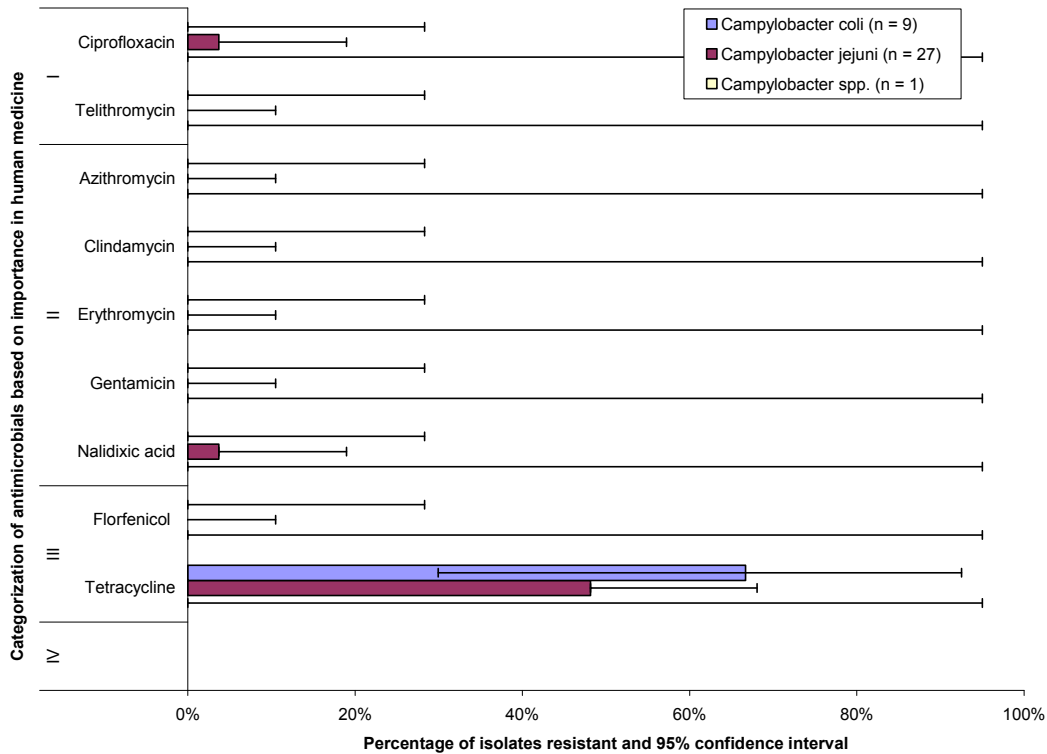


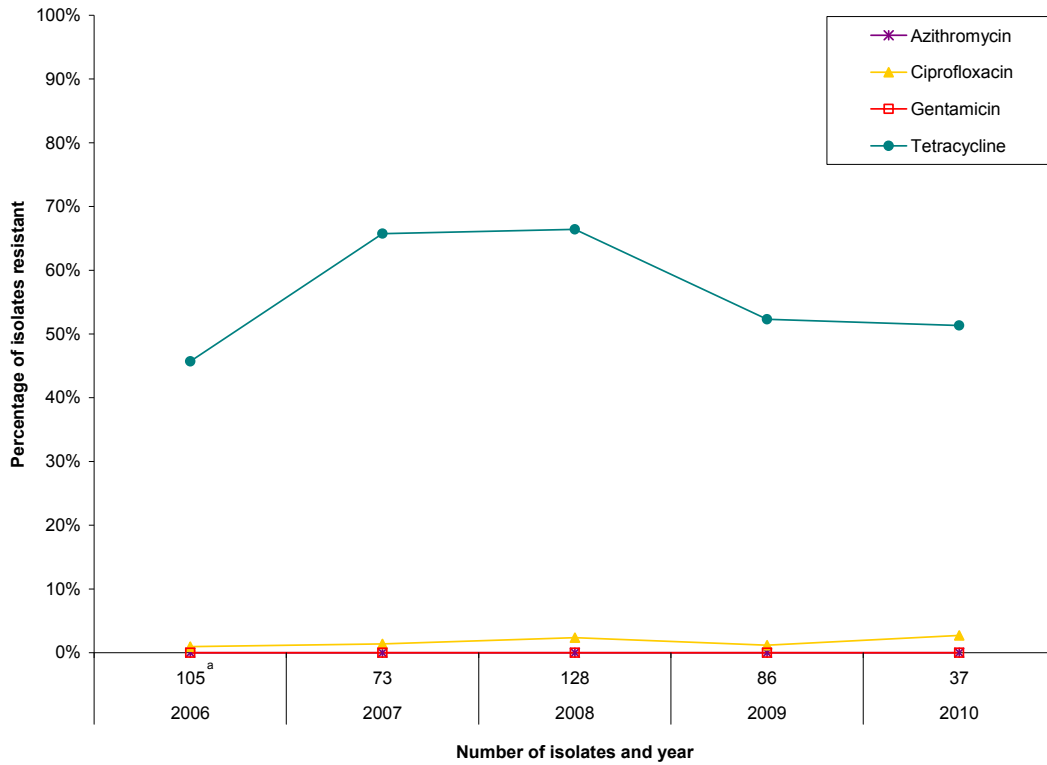
Table 11. Number of antimicrobial classes in resistance patterns of *Campylobacter* isolates from beef cattle; *Abattoir Surveillance*, 2010.

Species	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial													
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides	Ketolides	Lincosamides	Macrolides	Phenicol	Quinolones	Tetracyclines		
		0	1	2-3	4-5	6-7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET
<i>Campylobacter jejuni</i>	27 (73.0)	14	12	1								1	1	13	
<i>Campylobacter coli</i>	9 (24.3)	3	6											6	
<i>Campylobacter spp.</i>	1 (2.7)	1													
Total	37 (100)	18	18	1								1	1	19	

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

¹ In 2010, the number of samples received from abattoir beef cattle was much lower than anticipated due to a 55% drop in submissions related to unavoidable operational issues at 2 major participating abattoirs.

Figure 9. Temporal variation in resistance to selected antimicrobials in *Campylobacter* isolates from beef cattle; *Abattoir Surveillance, 2006–2010*.



In 2010, the number of samples received from abattoir beef cattle was much lower than anticipated due to a 55% drop in submissions related to unavoidable operational issues at 2 major participating abattoirs.

^a This number of isolates includes isolates from the end of year 2005 (n = 23).

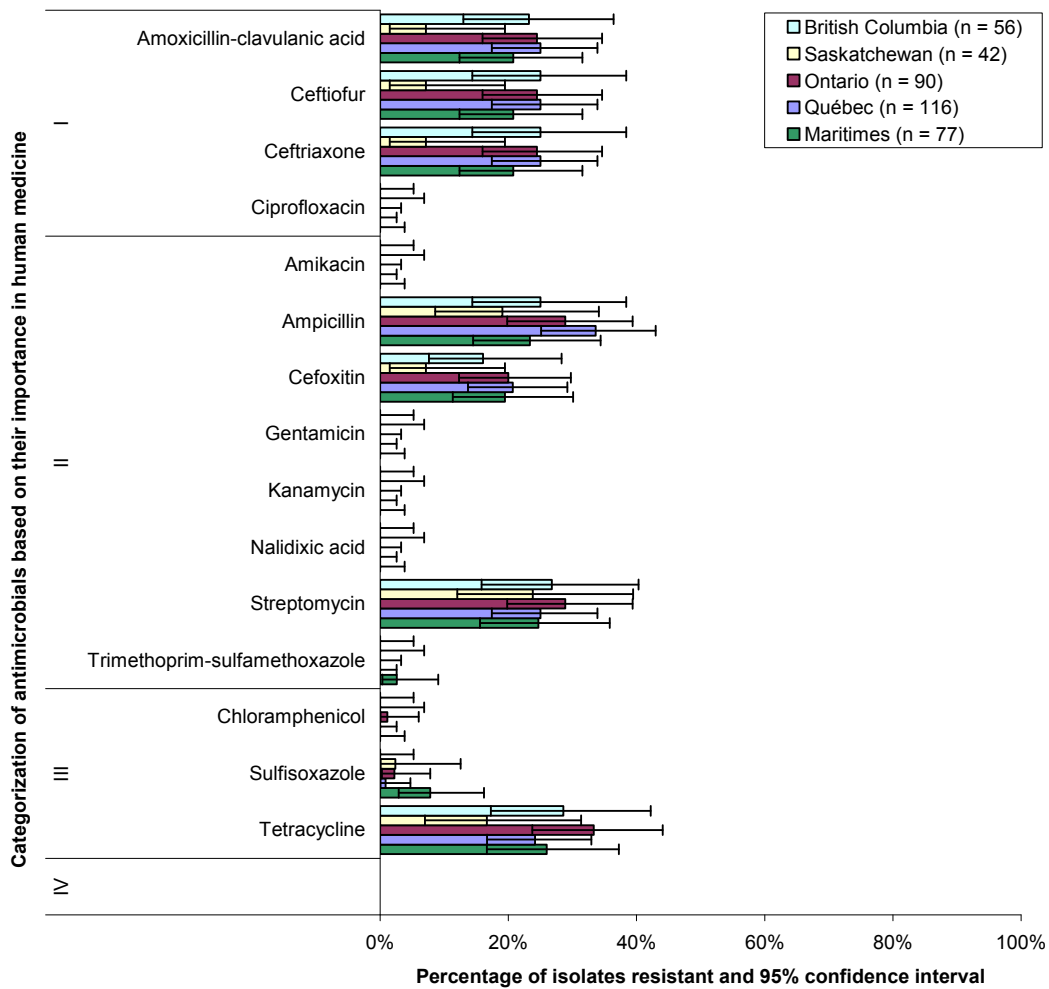
Chickens

Salmonella

Retail Meat Surveillance

(n = 381)

Figure 10. Resistance to antimicrobials in *Salmonella* isolates from chicken; Retail Meat Surveillance, 2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Table 12. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2010.

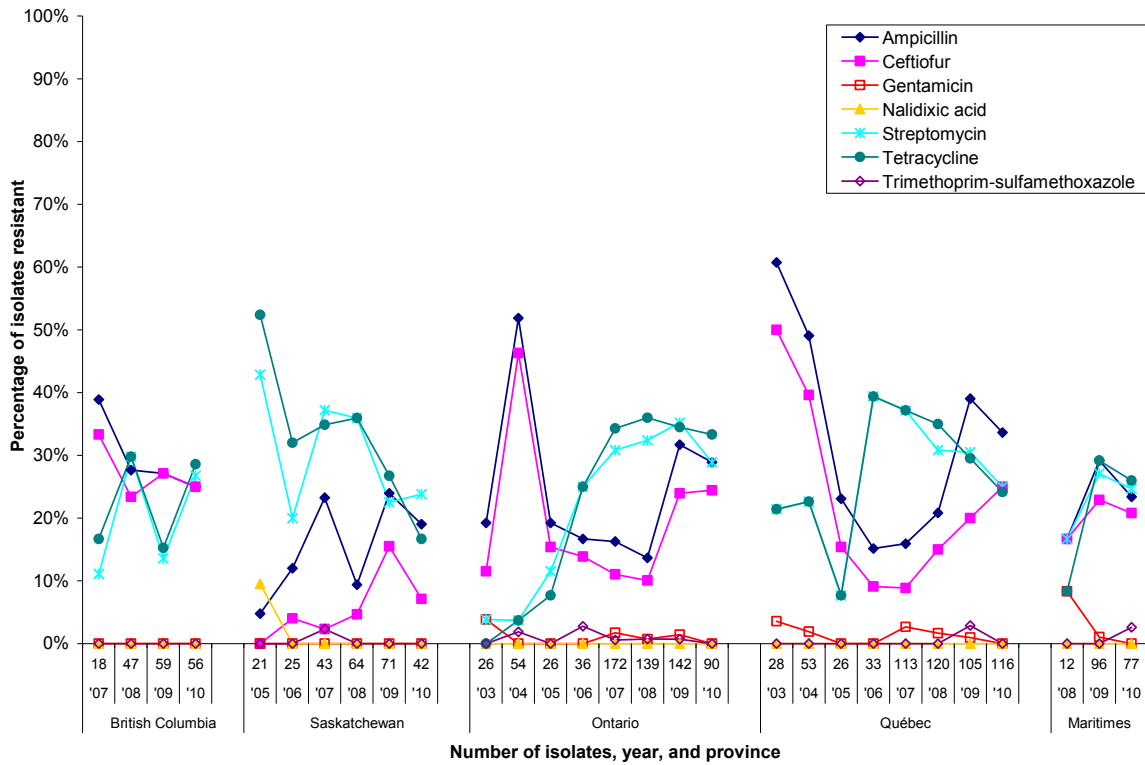
Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial															
							Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicol	Quinolones		Tetracyclines	
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET	
British Columbia																						
Enteritidis	24 (42.9)	24																				
Kentucky	18 (32.1)	1	3	14						14	12	11	12	7	12						15	
Heidelberg	4 (7.1)	2	2						2	2	2	2	2									
Hadar	3 (5.4)	2	1							1											1	
Less common serovars	7 (12.5)	7																				
Total	56 (100)	36	5	15						15	14	13	14	9	14						16	
Saskatchewan																						
Enteritidis	11 (26.2)	11																				
Heidelberg	8 (19.0)	3	3	2						2	5	1	1	1	1							
Hadar	3 (7.1)	3								3											3	
Braenderup	2 (4.8)	2																				
Kentucky	2 (4.8)	2								2	1	1	1	1	1						2	
Kiambu	2 (4.8)	2																				
Mbandaka	2 (4.8)	2																				
Schwarzengrund	2 (4.8)	2																				
Thompson	2 (4.8)	1	1						2											1		
Typhimurium	2 (4.8)	2																				
Agona	1 (2.4)	1								1	1											1
Albany	1 (2.4)	1																				
I 4,[5],12:i-	1 (2.4)	1																			1	
Illia 23:g,z51-	1 (2.4)	1																				
Infantis	1 (2.4)	1																				
Montevideo	1 (2.4)	1						1	1	1	1	1	1									
Total	42 (100)	27	6	9						10	8	3	3	3	3	3	1			7		
Ontario																						
Kentucky	31 (34.4)	11	2	18						18	12	12	12	8	12						18	
Heidelberg	18 (20.0)	9	8	1						8	4	4	4	4	1						1	
Hadar	9 (10.0)	2	7						7											9		
Enteritidis	6 (6.7)	6																				
Typhimurium	6 (6.7)	6																				
Schwarzengrund	5 (5.6)	4	1						1	1	1	1	1									
Typhimurium var. 5-	4 (4.4)	4																				
Thompson	3 (3.3)	2	1						1	1	1	1	1									
Kiambu	2 (2.2)	2																				
Less common serovars	6 (6.7)	1	4	1						1	4	4	4	4	4	1	1			2		
Total	90 (100)	45	18	26	1						26	26	22	22	18	22	2	1			30	
Québec																						
Heidelberg	49 (42.2)	29	18	2						2	20	10	10	9	10							
Kentucky	29 (25)	8	1	20						20	10	10	10	8	10						21	
Enteritidis	7 (6.0)	7																				
Hadar	4 (3.4)	4								4											4	
Albany	3 (2.6)	1	2						2	2	2	2	2									
Litchfield	3 (2.6)	2	1						1	1	1	1	1									
Thompson	3 (2.6)	2	1						1	1	1						1					
Less common serovars	18 (15.5)	12	3	3						3	5	5	5	4	5	1			3			
Total	116 (100)	61	26	29						29	39	29	29	24	29	1			28			
Maritimes																						
Heidelberg	27 (35.1)	16	9	2						3	7	6	6	6	6	3	2					
Kentucky	20 (26)	4	2	14						12	7	6	6	5	6	1			14			
Enteritidis	12 (15.6)	12																				
Albany	4 (5.2)	4								4	4	4	4	4								
Hadar	4 (5.2)	4								4											4	
Less common serovars	10 (13.0)	8	2																	2		
Total	77 (100)	40	15	22						19	18	16	16	15	16	6	2			20		

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

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Figure 11. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chicken; *Retail Meat Surveillance*, 2003–2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Abattoir Surveillance

(n = 142)

Figure 12. Resistance to antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2010.

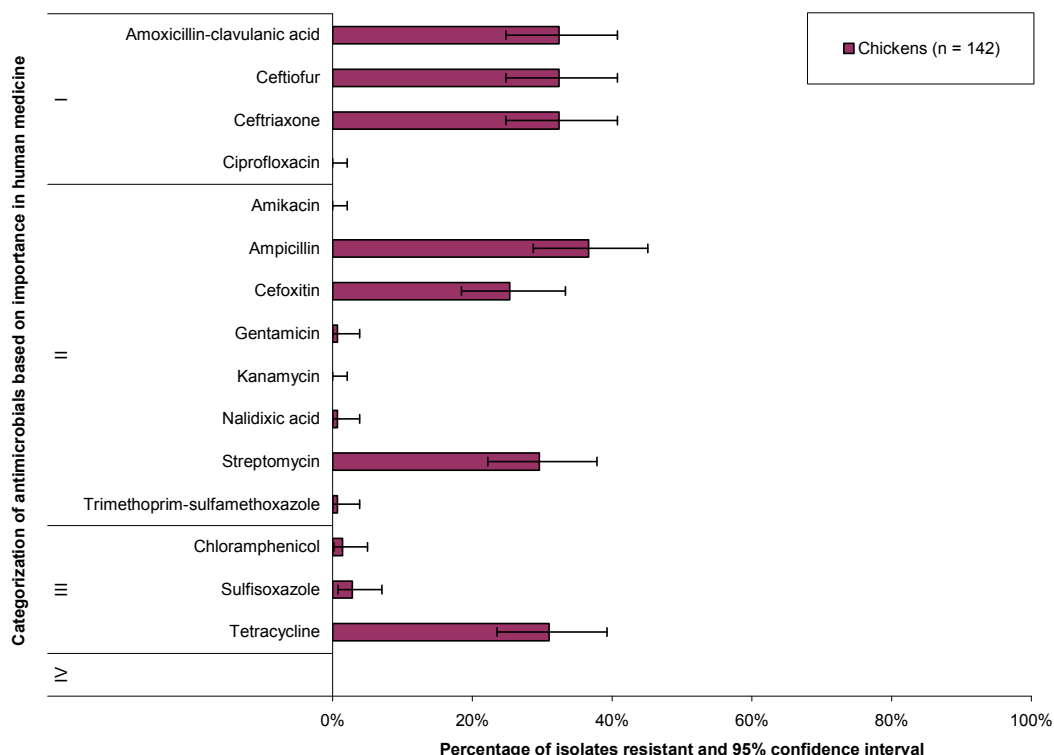


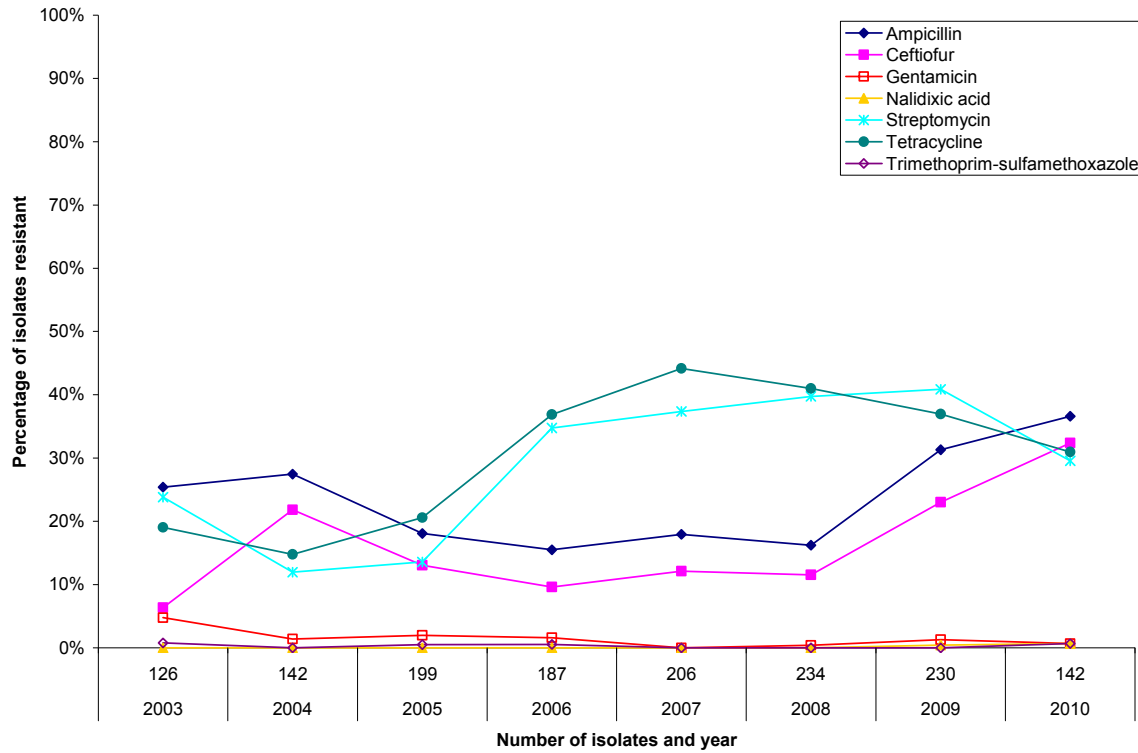
Table 13. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from chickens; *Abattoir Surveillance*, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern				Number of isolates resistant by antimicrobial class and antimicrobial															
						Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET
Kentucky	59 (41.5)	14	9	35	1				36	31	31	31	21	31						1	38
Heidelberg	30 (21.1)	13	17		1				16	10	10	10	10	1	1						
Enteritidis	25 (17.6)	25																			
Typhimurium	6 (4.2)	6																			
Litchfield	4 (2.8)	4																			
Hadar	3 (2.1)	1	2					2													2
Less common serovars	15 (10.6)	8	3	2	2	1	4	5	5	5	5	5	5	3			2				4
Total	142 (100)	71	29	39	3	1	42	52	46	46	36	46	4	1	2	1	2	1	44		

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

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

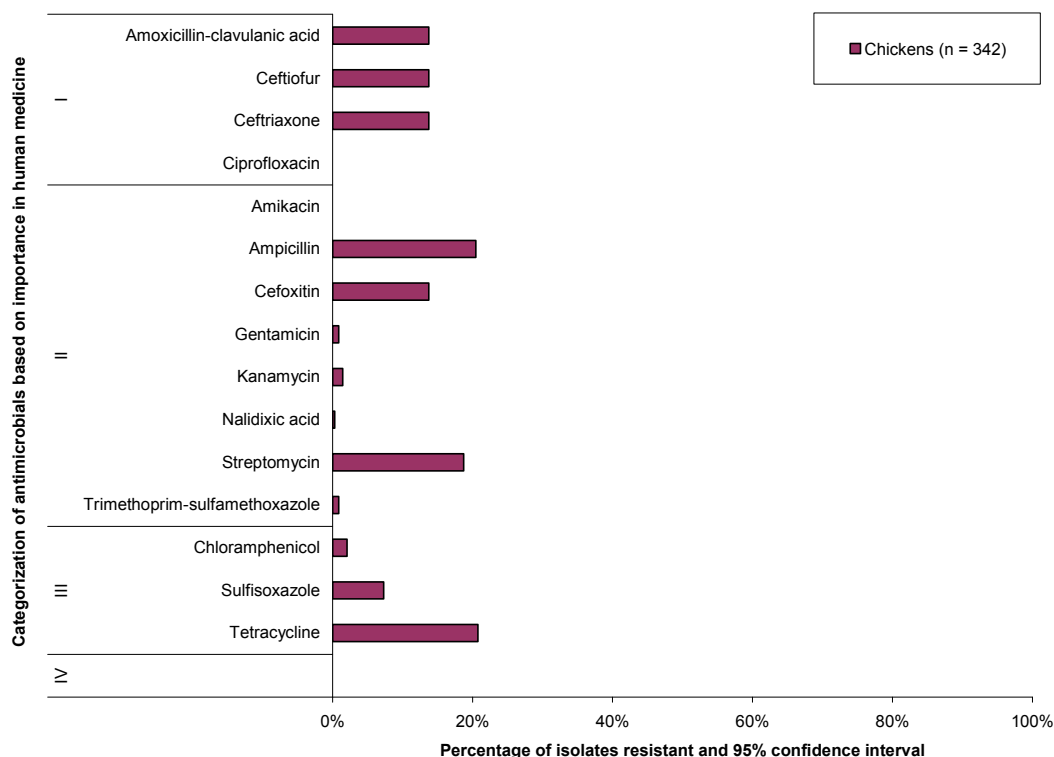
Figure 13. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from chickens; *Abattoir Surveillance, 2003–2010*.



Surveillance of Animal Clinical Isolates

(n = 342)

Figure 14. Resistance to antimicrobials in *Salmonella* isolates from chickens; *Surveillance of Animal Clinical Isolates*, 2010.



Confidence intervals are not displayed for animal clinical data because samples were not obtained randomly and may not represent independent observations

Table 14. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from chickens; *Surveillance of Animal Clinical Isolates*, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial															
		0	1	2-3	4-5	6	Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
							AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET	
Enteritidis	114 (33.3)	110	2	1	1		1		1	2	1	1	1	1	2		1		1	2		
Heidelberg	95 (27.8)	63	24	8				1	4	30	13	13	13	13	4					5		
Kentucky	68 (19.9)	16	10	42					38	26	26	26	26	26						47		
Typhimurium	13 (3.8)	10			3			1	3	3					3	1		3		3		
Mbandaka	9 (2.6)	2		7					7						7					7		
I 4,[5],12:i:-	8 (2.3)	6	1	1				1		1	1	1	1	1						1		
Less common serovars	35 (10.2)	21	3	8	3			2	2	11	8	6	6	6	6	9	2		3	6		
Total	342 (100)	228	40	67	7			3	5	64	70	47	47	47	47	25	3		7	1	71	

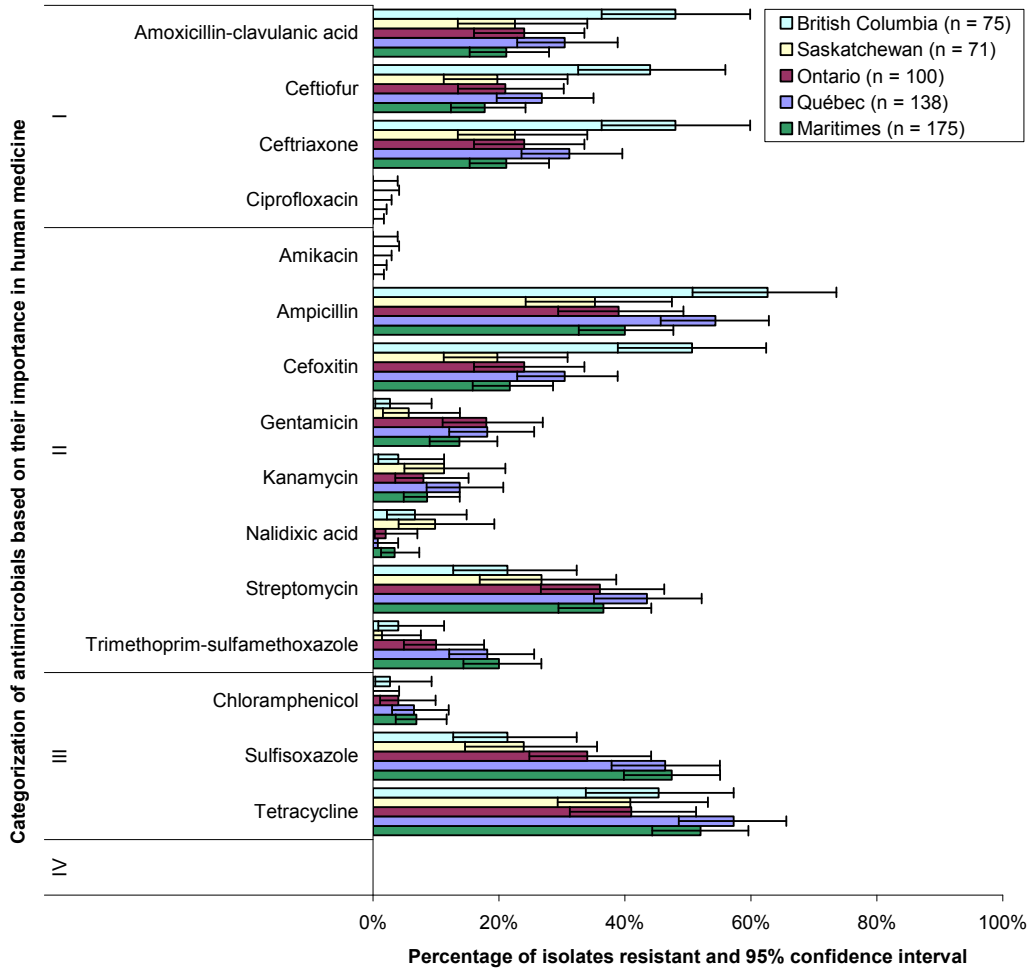
Serovars represented by less than 2% of isolates were classified as “Less common serovars”. Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Escherichia coli

Retail Meat Surveillance

(n = 559)¹

Figure 15. Resistance to antimicrobials in *Escherichia coli* isolates from chicken; Retail Meat Surveillance, 2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

¹ One isolate from the Maritimes could not be cultured after freezing, leaving 559 isolates available for antimicrobial susceptibility testing.

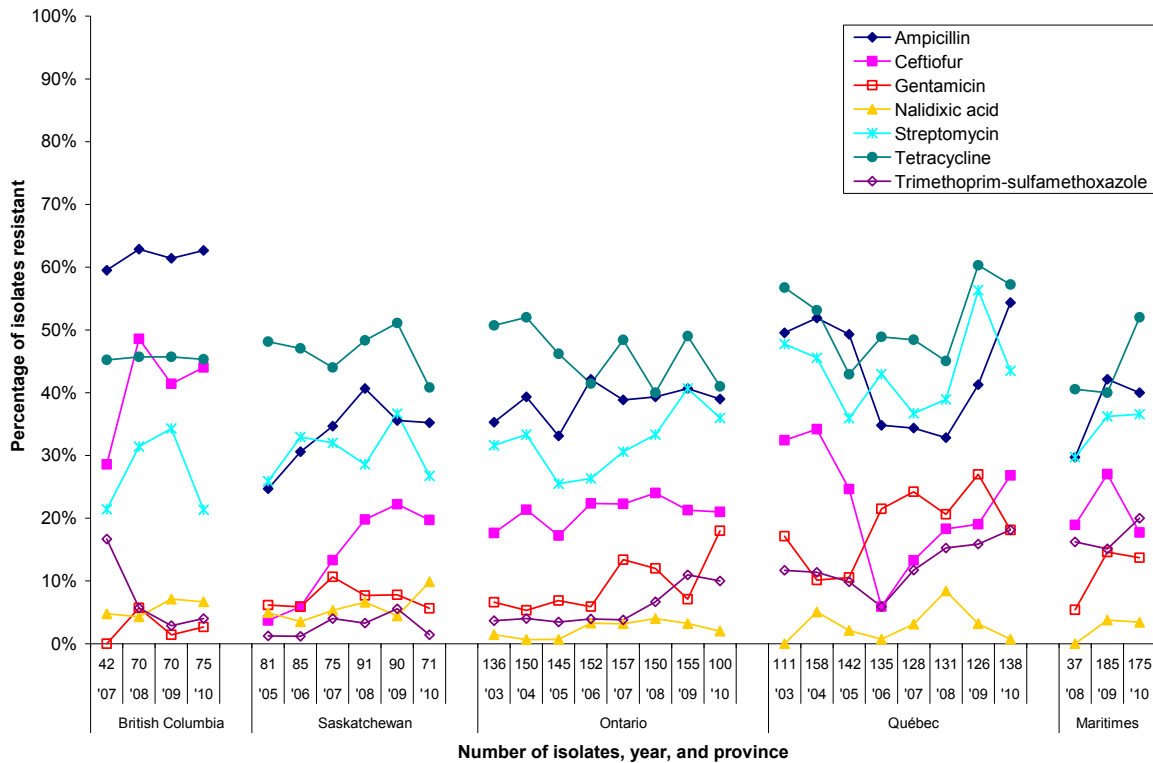
Table 15. Number of antimicrobial classes in resistance patterns of *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2010.

Province	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																				
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET	
British Columbia	75 (13.4)	17	25	23	10	2	3	16	47	36	36	38	33	16	3	2			5	34		
Saskatchewan	71 (12.7)	20	17	32	2	4	8	19	25	16	16	14	14	17	1			7	29			
Ontario	100 (17.9)	29	22	40	9	18	8	36	39	24	24	21	34	10	4			2	41			
Québec	138 (24.7)	24	25	64	25	25	19	60	75	42	43	42	37	64	25	9		1	79			
Maritimes	175 (31.3)	47	29	59	39	24	15	64	70	37	37	38	31	83	35	12		6	91			

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Figure 16. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chicken; *Retail Meat Surveillance*, 2003–2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Abattoir Surveillance

(n = 119)

Figure 17. Resistance to antimicrobials in *Escherichia coli* isolates from chickens; Abattoir Surveillance, 2010.

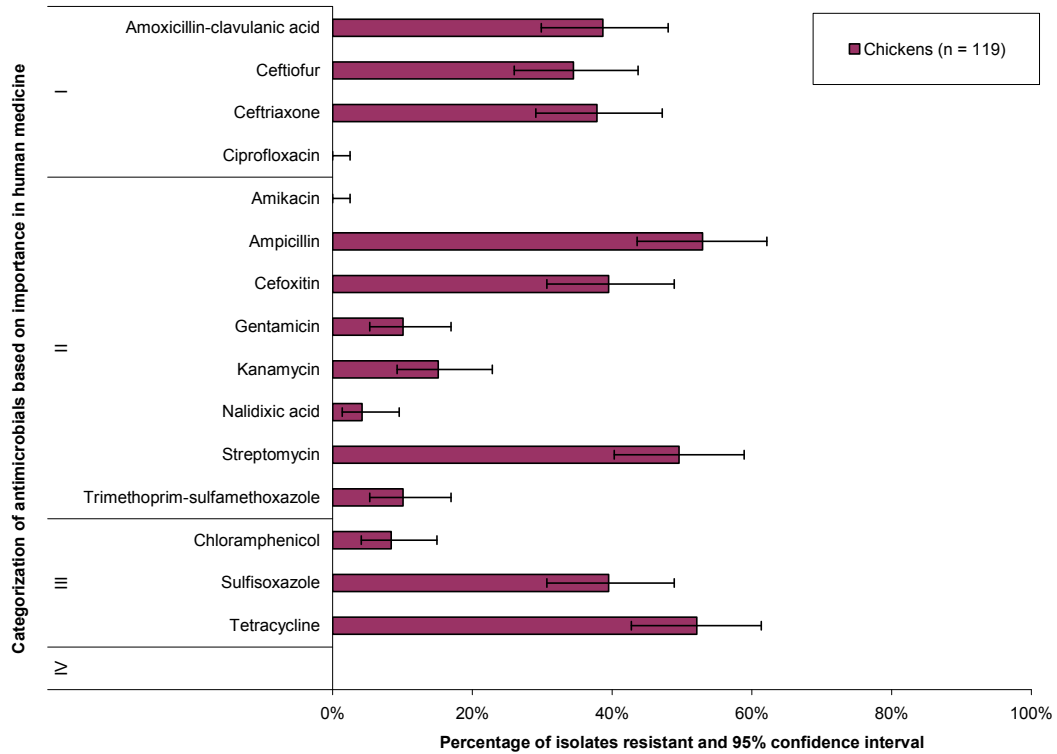
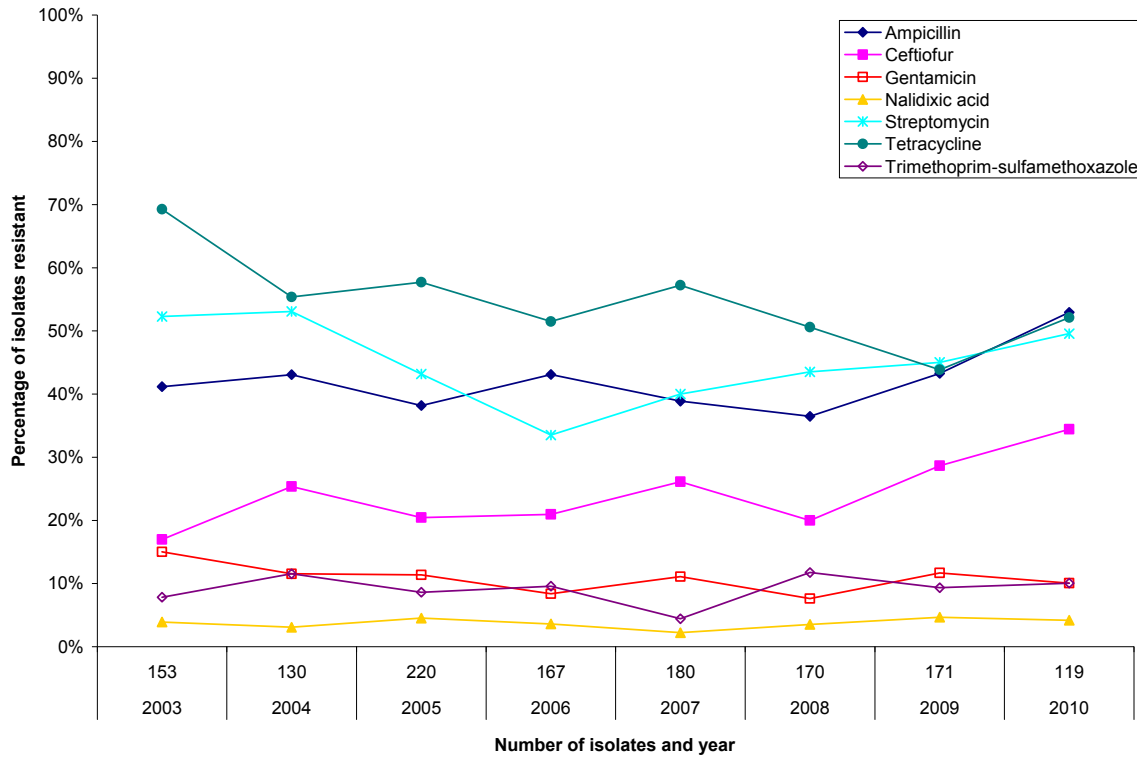


Figure 18. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from chickens; *Abattoir Surveillance, 2003–2010*.



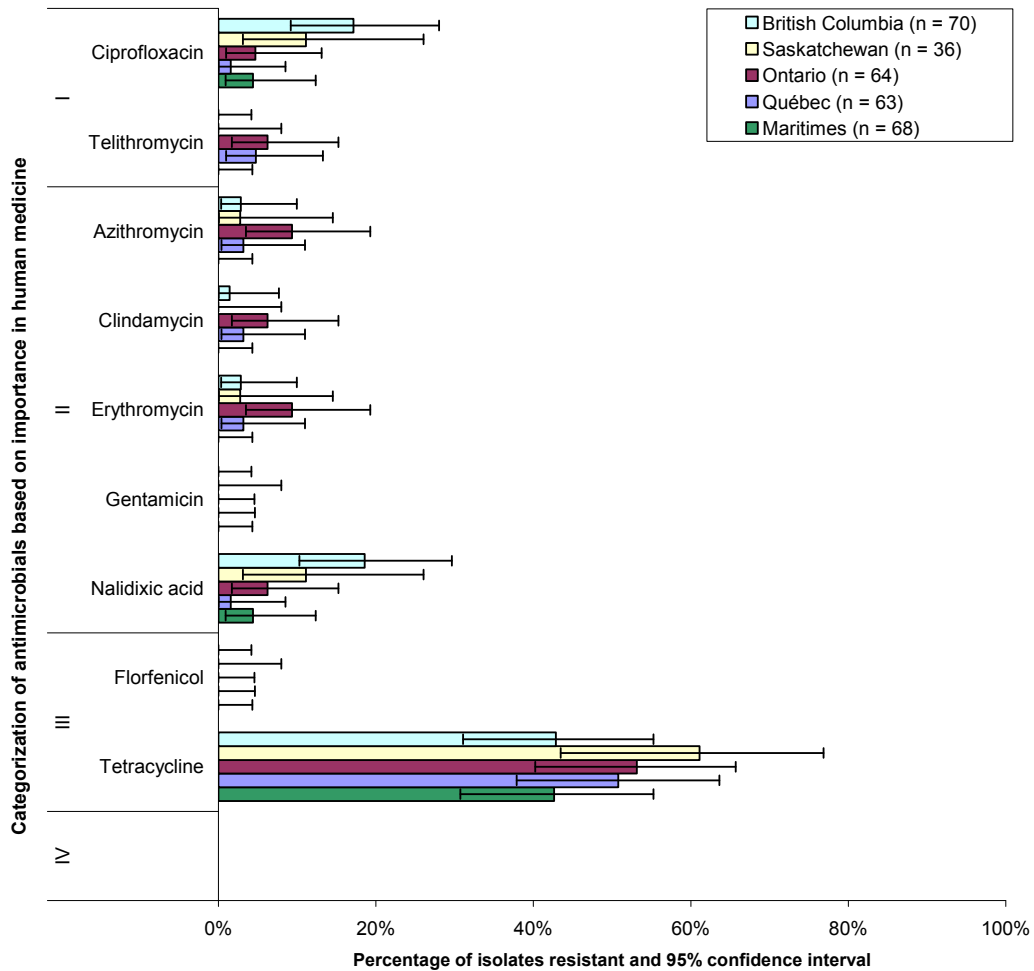
Results regarding the number of antimicrobial classes in resistance patterns of abattoir *E. coli* isolates from chickens can be found in Table 10.

Campylobacter

Retail Meat Surveillance

(n = 301)¹

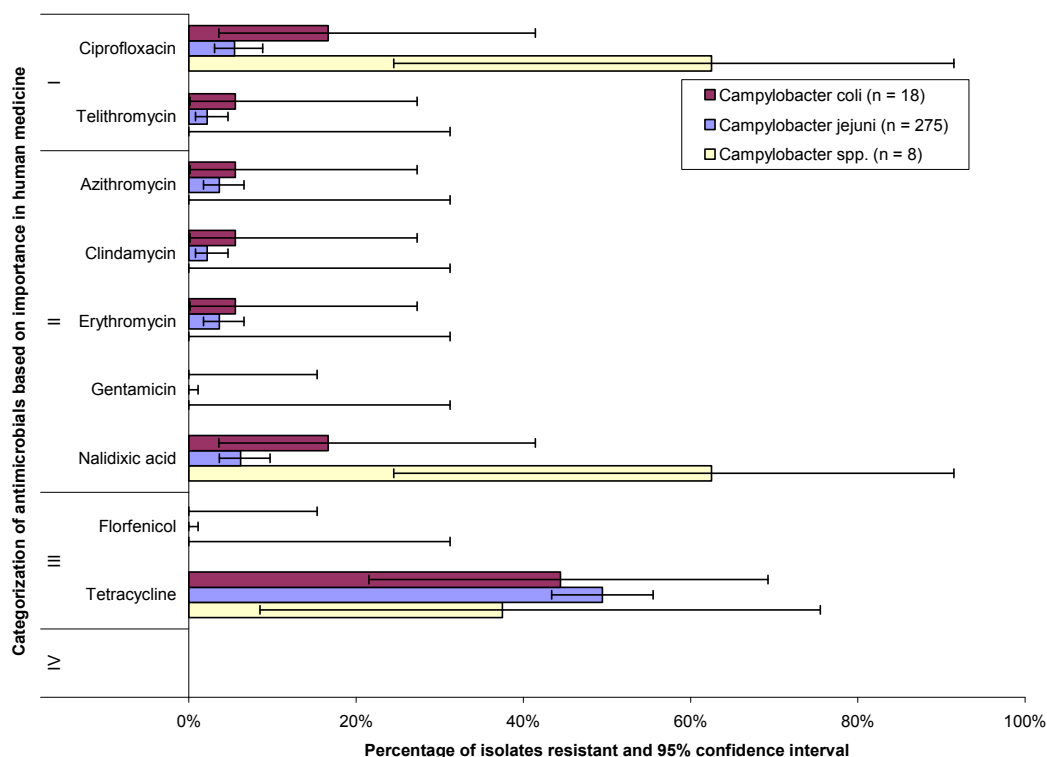
Figure 19. Resistance to antimicrobials in *Campylobacter* isolates from chicken, by province; Retail Meat Surveillance, 2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

¹ One isolate from Saskatchewan and 2 from the Maritimes could not be cultured after freezing, leaving 301 isolates available for antimicrobial susceptibility testing.

Figure 20. Resistance to antimicrobials in *Campylobacter* isolates from chicken, by *Campylobacter* species; Retail Meat Surveillance, 2010.



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

Table 16. Number of antimicrobial classes in resistance patterns of *Campylobacter* isolates from chicken; Retail Meat Surveillance, 2010.

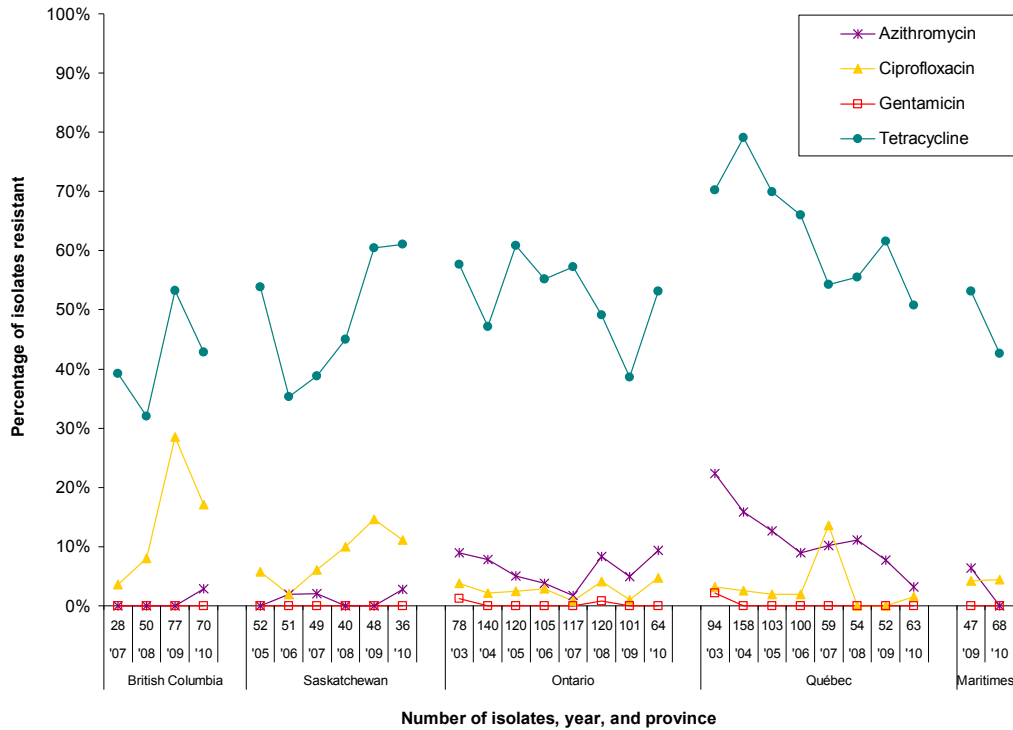
Province or region / Species	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial												
		Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial							
		0	1	2-3	4-5	6-7	Aminoglycosides (GEN)	Ketolides (TEL)	Lincosamides (CLI)	Macrolides (AZM, ERY)	Phenicol (FLR)	Quinolones (CIP, NAL)	Tetracyclines (TET)	
British Columbia														
<i>Campylobacter jejuni</i>	62 (88.6)	31	23	8				1	2	2		9	10	26
<i>Campylobacter coli</i>	4 (5.7)	2	1	1								1	1	2
<i>Campylobacter</i> spp.	4 (5.7)	1	2	1								2	2	2
Total	70 (100)	34	26	10				1	2	2		12	13	30
Saskatchewan														
<i>Campylobacter jejuni</i>	34 (94.4)	11	21	2					1	1		3	3	21
<i>Campylobacter</i> spp.	2 (5.6)		2									1	1	1
Total	36 (100)	11	23	2					1	1		4	4	22
Ontario														
<i>Campylobacter jejuni</i>	58 (90.6)	22	29	5	2			4	4	6	6	2	3	31
<i>Campylobacter coli</i>	6 (9.4)	2	4									1	1	3
Total	64 (100)	24	33	5	2			4	4	6	6	3	4	34
Québec														
<i>Campylobacter jejuni</i>	58 (92.1)	26	31		1			2	1	1	1			31
<i>Campylobacter coli</i>	4 (6.3)	2	1	1				1	1	1	1			1
<i>Campylobacter</i> spp.	1 (1.6)		1											1
Total	63 (100)	28	33	1	1			3	2	2	2	1	1	32
Maritimes														
<i>Campylobacter jejuni</i>	63 (92.6)	35	28									1	1	27
<i>Campylobacter coli</i>	4 (5.9)	2	1	1								1	1	2
<i>Campylobacter</i> spp.	1 (1.5)		1									1	1	1
Total	68 (100)	37	30	1								3	3	29

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

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Figure 21. Temporal variation in resistance to selected antimicrobials in *Campylobacter* isolates from chicken; *Retail Meat Surveillance, 2003–2010*.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island. Although routine retail surveillance began in the Maritimes region in 2008, no results are displayed for that year due to concerns regarding harmonization of laboratory methods.

Abattoir Surveillance

(n = 111)

Figure 22. Resistance to antimicrobials in *Campylobacter* isolates from chickens; *Abattoir Surveillance*, 2010.

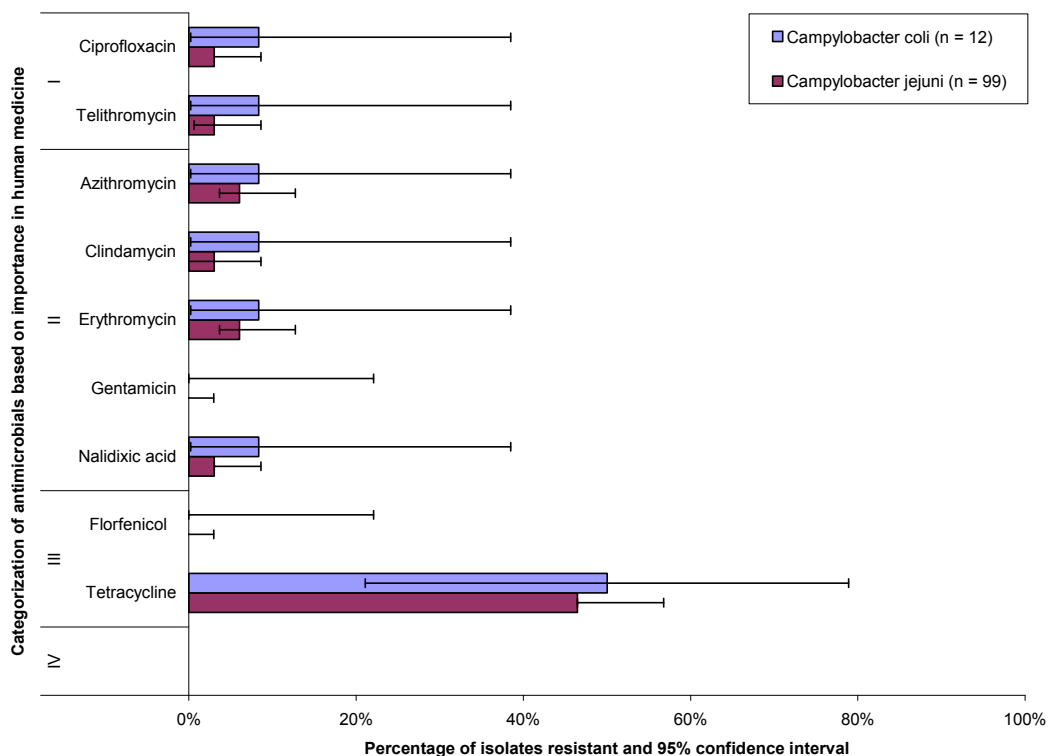


Table 17. Number of antimicrobial classes in resistance patterns of *Campylobacter* isolates from chickens; *Abattoir Surveillance*, 2010.

Species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial													
		0	1	2-3	4-5	6-7	Aminoglycosides		Ketolides		Lincosamides		Macrolides		Phenicols		Quinolones		Tetracyclines	
		GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET										
<i>Campylobacter jejuni</i>	99 (89.2)	49	42	8					3	3	6	6			3	3				46
<i>Campylobacter coli</i>	12 (10.8)	5	6	1					1	1	1	1			1	1				6
Total	111 (100)	54	48	8	1				4	4	7	7			4	4				52

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Pigs

Salmonella

Abattoir Surveillance

(n = 182)

Figure 23. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2010.

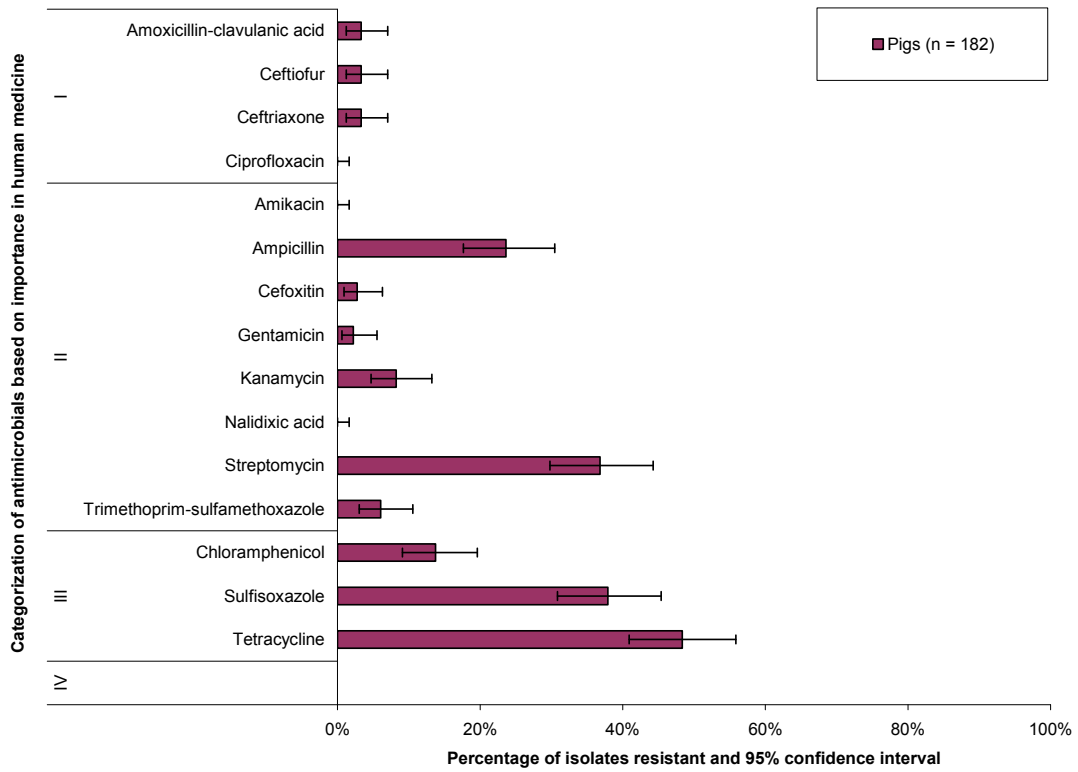


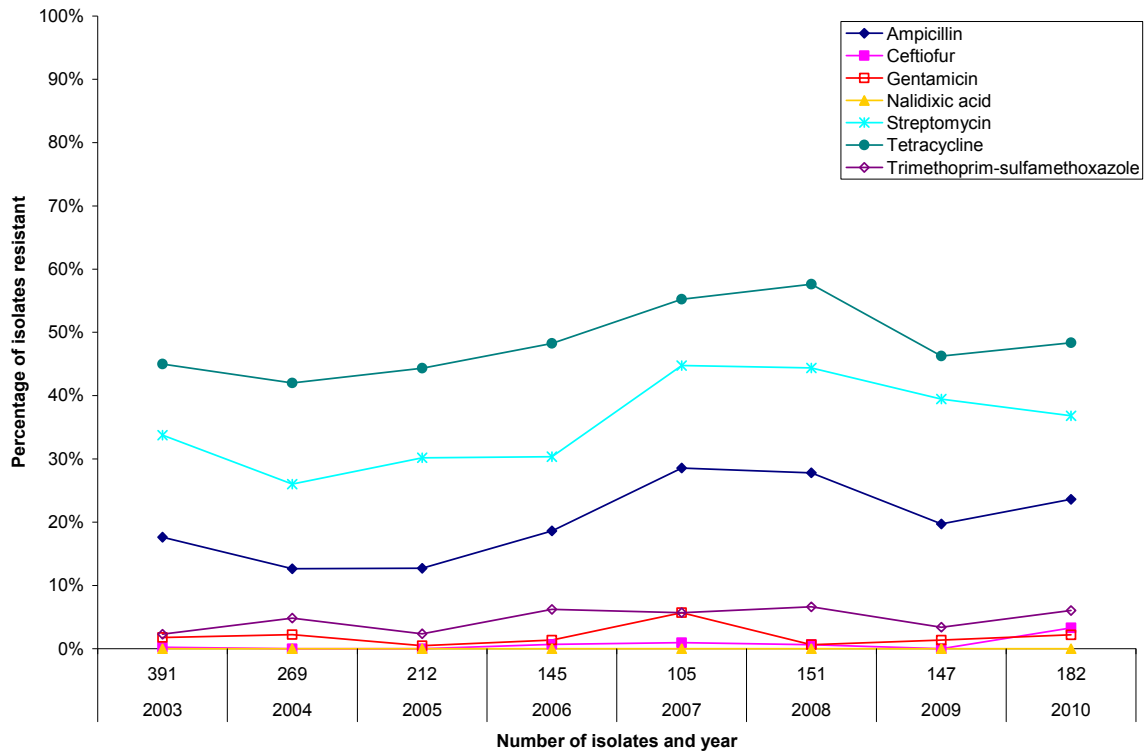
Table 18. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial																		
		0	1	2-3	4-5	6	Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicol	Quinolones		Tetracyclines				
							AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET				
Derby	36 (19.8)	7	6	23					1	22	1						25	4						25	
Infantis	22 (12.1)	16	4		2				2	1	5	3	3	3	3					2	2				2
Typhimurium var. 5-	21 (11.5)	1	1	6	13				5	16	15	2	1	1	1		18	4			12				19
Typhimurium	16 (8.8)	2	1	3	10						11	12					11				9				13
Brandenburg	15 (8.2)	11	1	3					1	1	1										1				4
Worthington	13 (7.1)	7	6																						6
Schwarzengrund	11 (6.0)	7		3	1						4	1	1	1	1		4				1				4
Mbandaka	6 (3.3)	2		3	1				3	3	4	1					4								4
Agona	5 (2.7)	4		1													1								1
Give	4 (2.2)	3			1					1	1						1				1				1
Ohio	4 (2.2)	3			1				1	1		1													1
Less common serovars	29 (15.9)	20	1	6	2				1	7	6			1		1	3	1			1				8
Total	182 (100)	83	20	49	30				4	15	67	43	6	6	5	6	69	11			25				88

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

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Figure 24. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from pigs; *Abattoir Surveillance*, 2003–2010.



Farm Surveillance

(n = 101)

Figure 25. Resistance to antimicrobials in *Salmonella* isolates from pigs; Farm Surveillance, 2010.

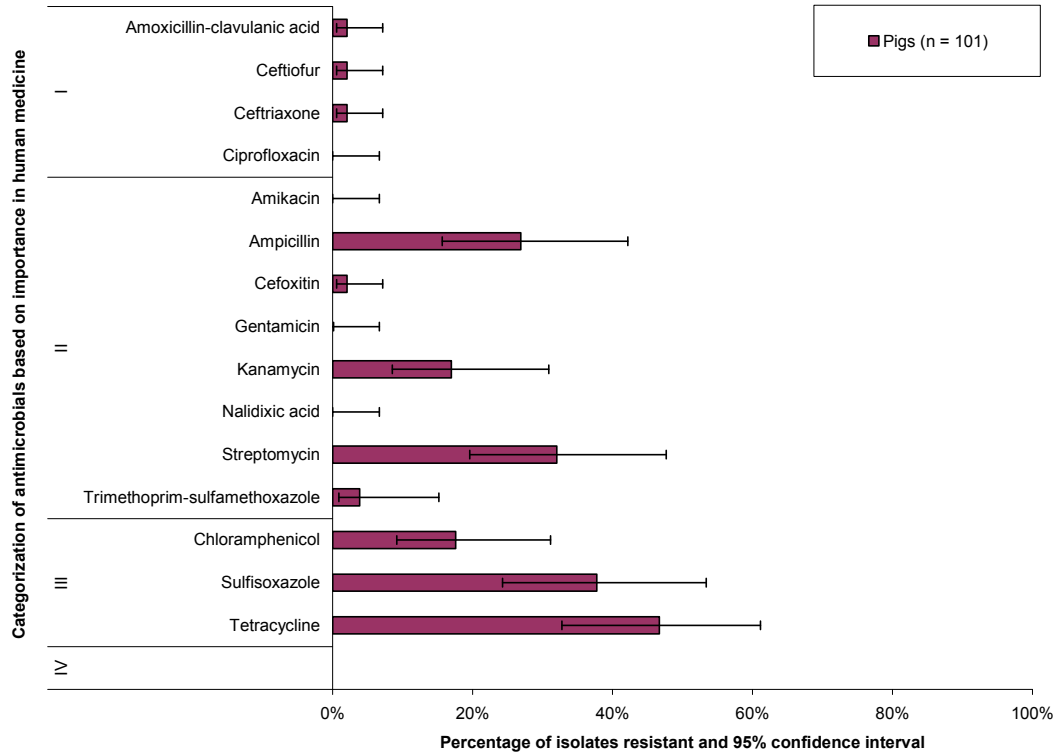


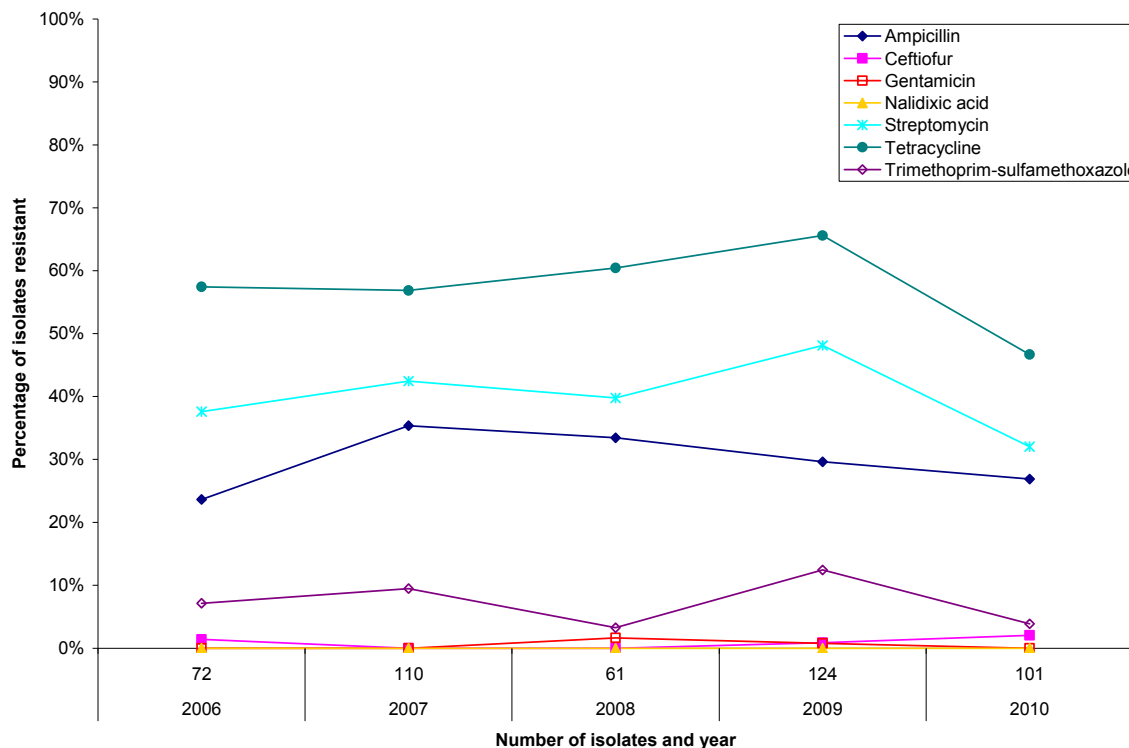
Table 19. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from pigs; Farm Surveillance, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern				Number of isolates resistant by antimicrobial class and antimicrobial															
						Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicol		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET
Typhimurium var. 5-	31 (30.7)	2	1	5	23			12	22	27	1	1	1	1	24	2	20				26
Derby	19 (18.8)	1	3	15				3	15						15						8
Infantis	14 (13.9)	11	3																		3
Brandenburg	11 (10.9)	6	5																		5
I 4,[5],12:i:-	6 (5.9)	1	3	1	1				2	1					1						5
Typhimurium	4 (4.0)			1	3			3	3	3					4	1	4				3
Bovismorbificans	2 (2.0)	2																			
Manhattan	2 (2.0)	2																			
Mbandaka	2 (2.0)	1		1					1						1						1
Ohio	2 (2.0)			2				1	2	1	1	1	1	1	2		2				2
Less common serovars	8 (7.9)	6		2											2						2
Total	101 (100)	32	15	25	29			19	45	32	2	2	2	2	49	3	26				55

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

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

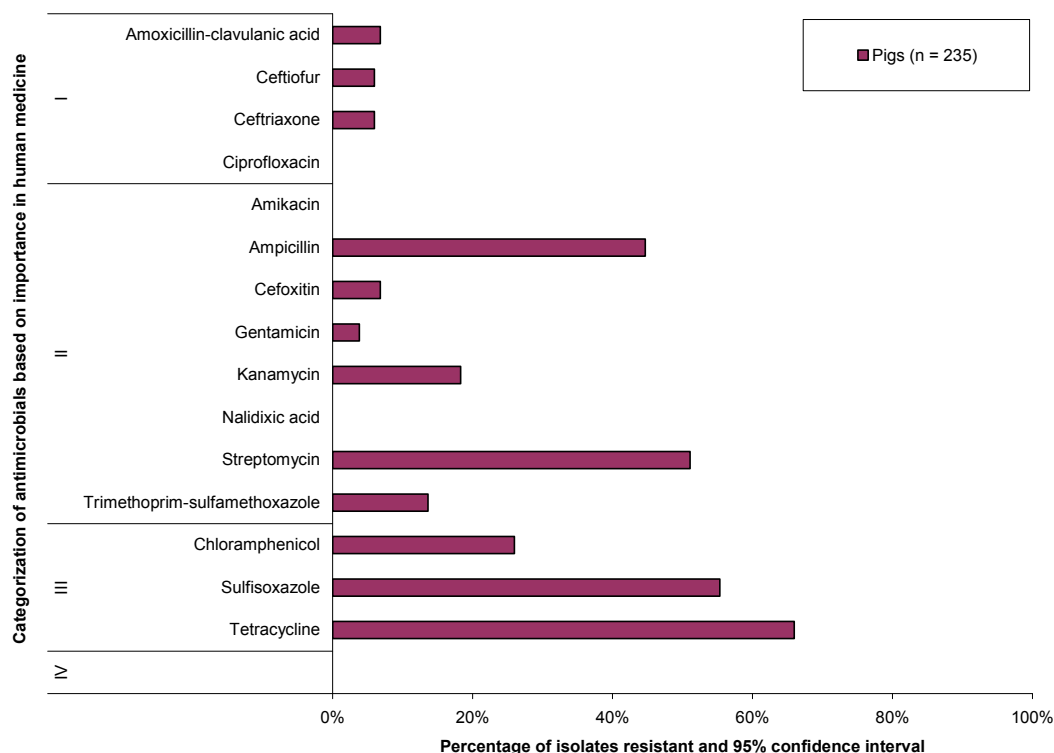
Figure 26. Temporal variation in resistance to selected antimicrobials in *Salmonella* isolates from pigs; *Farm Surveillance, 2006–2010*.



Surveillance of Animal Clinical Isolates

(n = 235)

Figure 27. Resistance to antimicrobials in *Salmonella* isolates from pigs; *Surveillance of Animal Clinical Isolates*, 2010.



Confidence intervals are not displayed for animal clinical data because samples were not obtained randomly and may not represent independent observations.

Table 20. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from pigs; *Surveillance of Animal Clinical Isolates*, 2010.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern				Number of isolates resistant by antimicrobial class and antimicrobial														
		0	1	2-3	4-5	Aminoglycosides				β-lactams				Folate pathway inhibitors		Phenicol		Quinolones		Tetracyclines
						AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET
Typhimurium	75 (31.9)	7	8	20	40	2	20	45	55	5	4	4	4	54	27	31			66	
Derby	38 (16.2)	12	4	20	2		1	22	2	1	1	2	1	22	1				25	
Typhimurium var. 5-I 4,[5],12:i:-	28 (11.9)	2	4	5	17	3	4	21	18	2	1	1	1	21	2	17			21	
Infantis	15 (6.4)	3			12	1	5	12	12					12	2	5			12	
Brandenburg	15 (6.4)	10	2	3			2	1	3	2	2	3	2	1		1			2	
Mbandaka	8 (3.4)	5	2	1			2	1	1					1		1			3	
Agona	8 (3.4)	3		4	1		2	3	1	1				3					5	
Less common serovars	6 (2.6)	2	1	2	1			1	1	2	2	2	2	3		1			3	
Less common serovars	42 (17.9)	18	8	8	8	1	5	17	11	4	4	4	4	13		5			18	
Total	235 (100)	62	27	64	82	9	43	120	105	16	14	16	14	130	32	61			155	

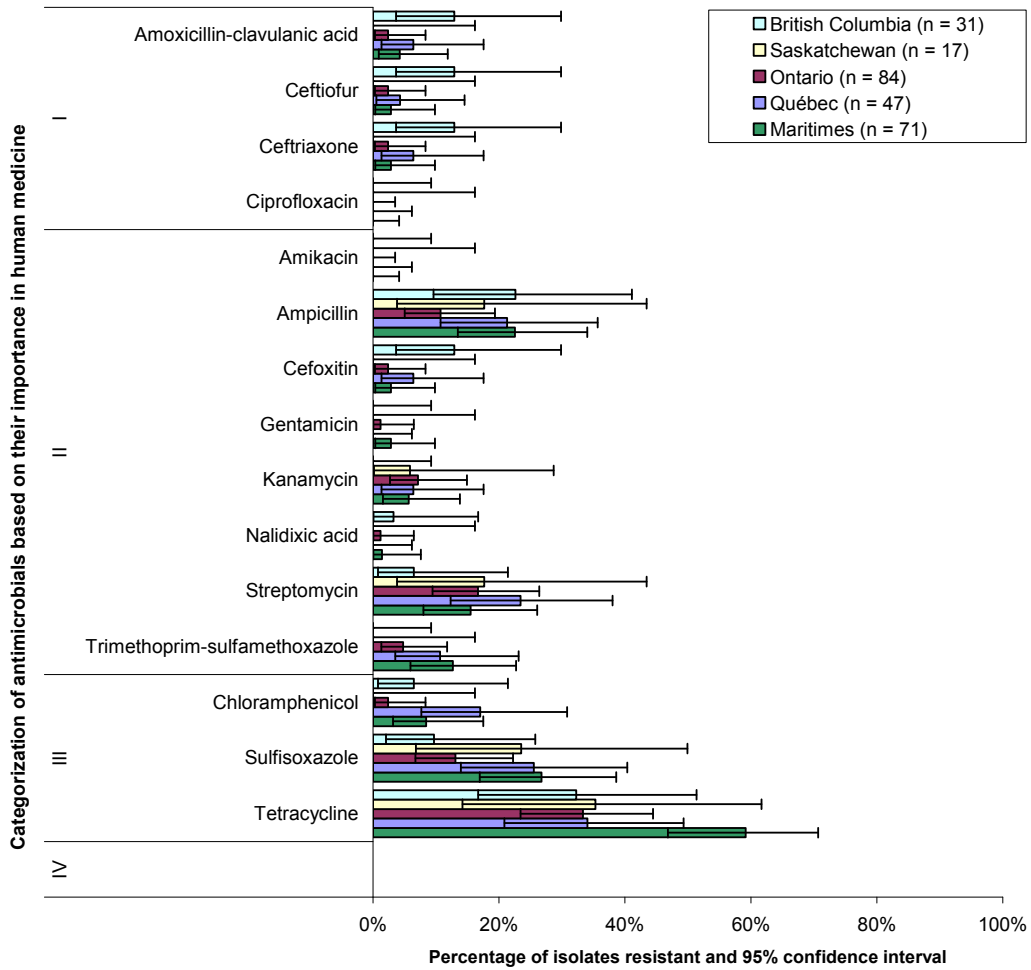
Serovars represented by less than 2% of isolates were classified as "Less common serovars". Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Escherichia coli

Retail Meat Surveillance

(n = 250)¹

Figure 28. Resistance to antimicrobials in *Escherichia coli* isolates from pork; Retail Meat Surveillance, 2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

¹ Three isolates from the Maritimes could not be cultured after freezing, leaving 250 isolates available for antimicrobial susceptibility testing.

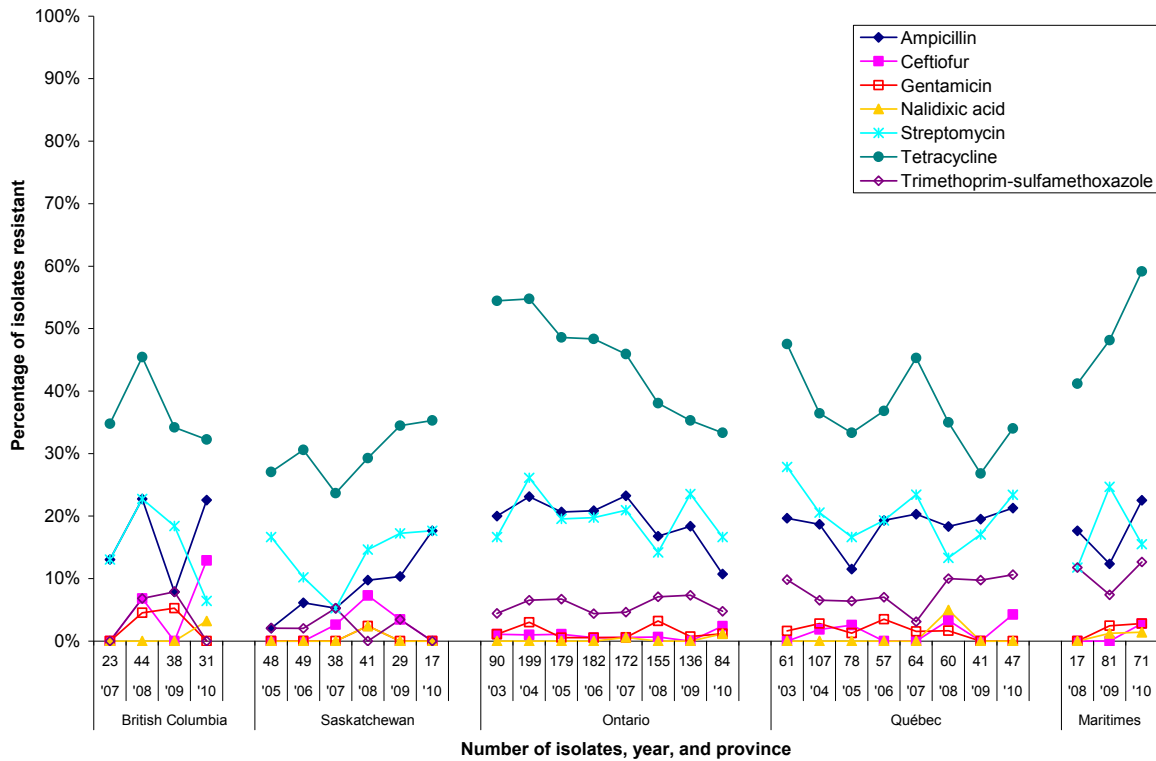
Table 21. Number of antimicrobial classes in resistance patterns of *Escherichia coli* isolates from pork; Retail Meat Surveillance, 2010.

Province	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																										
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides										β-lactams					Folate pathway inhibitors		Phenicol		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET							
British Columbia	31 (12.4)	19	5	5	2					2	7	4	4	4	4	3		2		1	10							
Saskatchewan	17 (6.8)	10	3	3	1				1	3	3				4						6							
Ontario	84 (33.6)	54	13	10	7	1	6	14	9	2	2	2	2	2	11	4	2		1	28								
Québec	47 (18.8)	26	3	12	6				3	11	10	3	3	3	2	5	8			16								
Maritimes	71 (28.4)	23	19	22	7	2	4	11	16	3	2	2	2	2	19	9	6		1	42								

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Figure 29. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pork; Retail Meat Surveillance, 2003–2010.



The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Abattoir Surveillance

(n = 199)

Figure 30. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; Abattoir Surveillance, 2010.

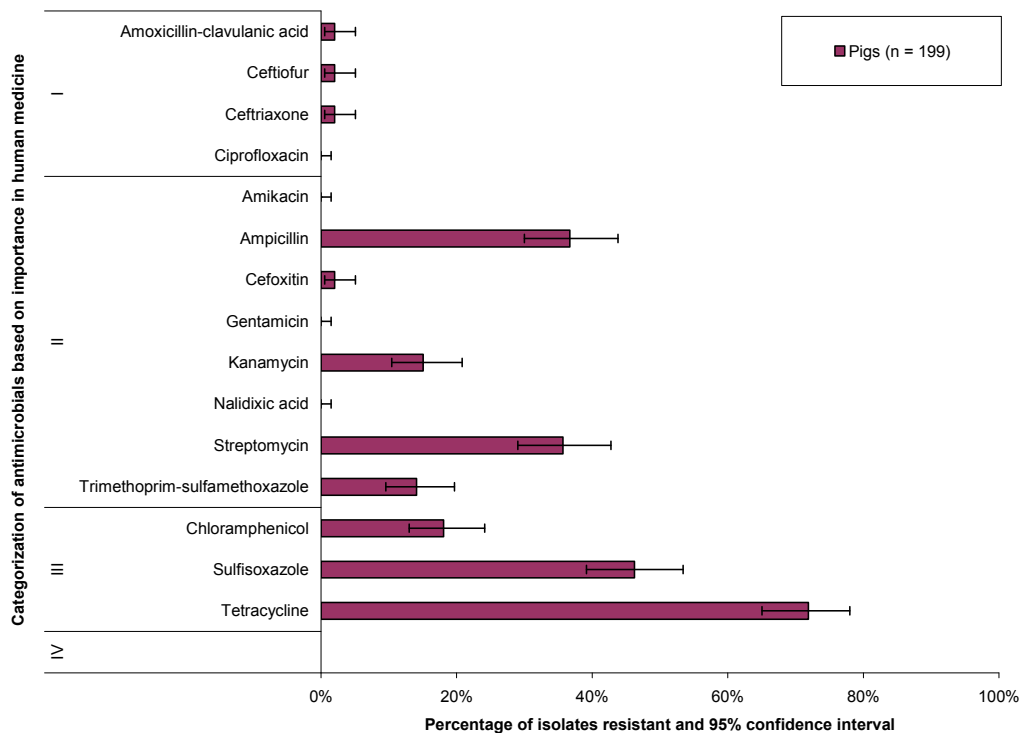
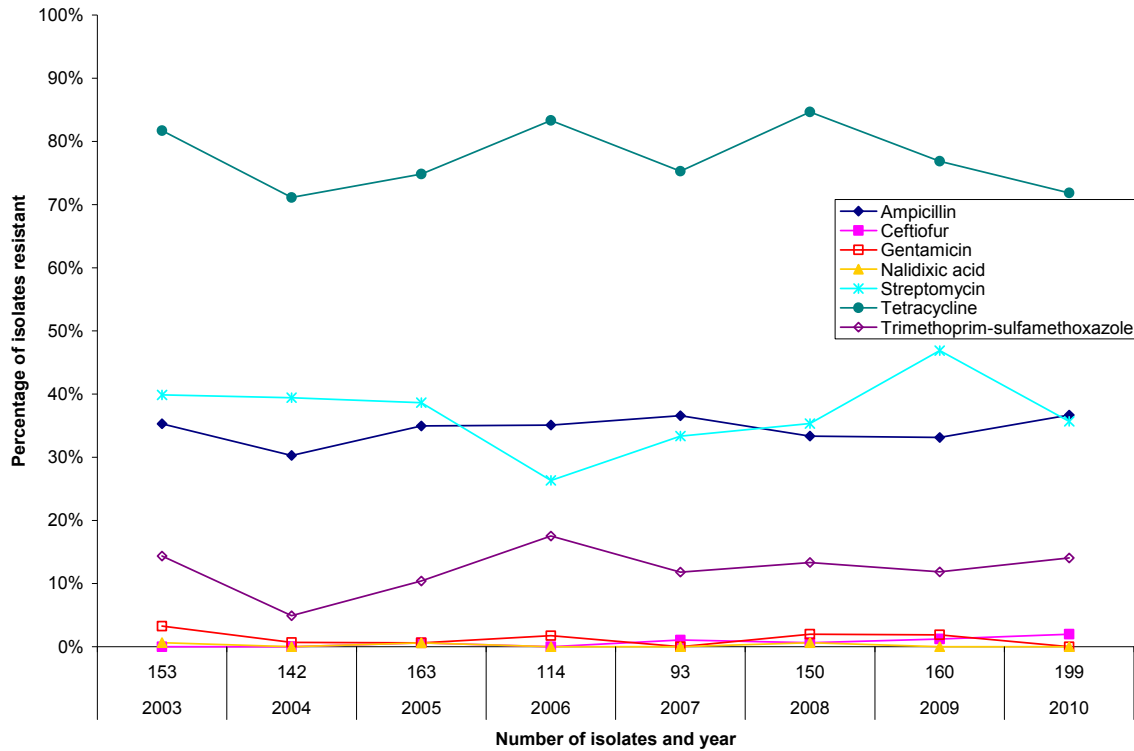


Figure 31. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pigs; Abattoir Surveillance, 2003–2010.

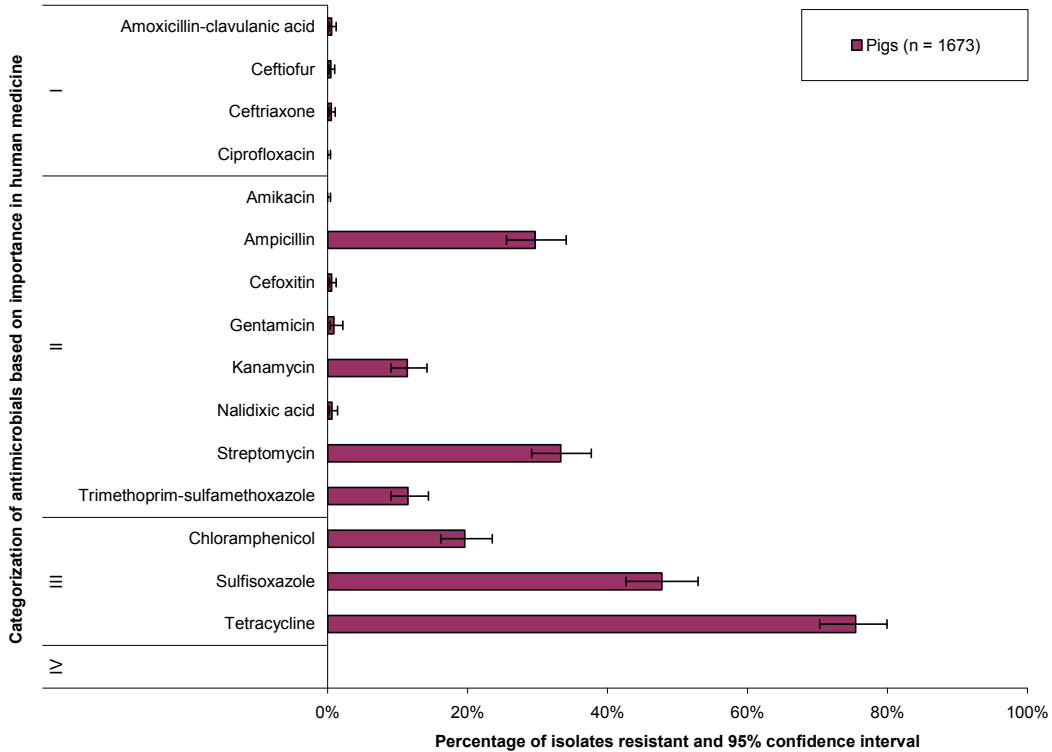


Results regarding the number of antimicrobial classes in resistance patterns of abattoir *E. coli* isolates from pigs can be found in Table 10.

Farm Surveillance

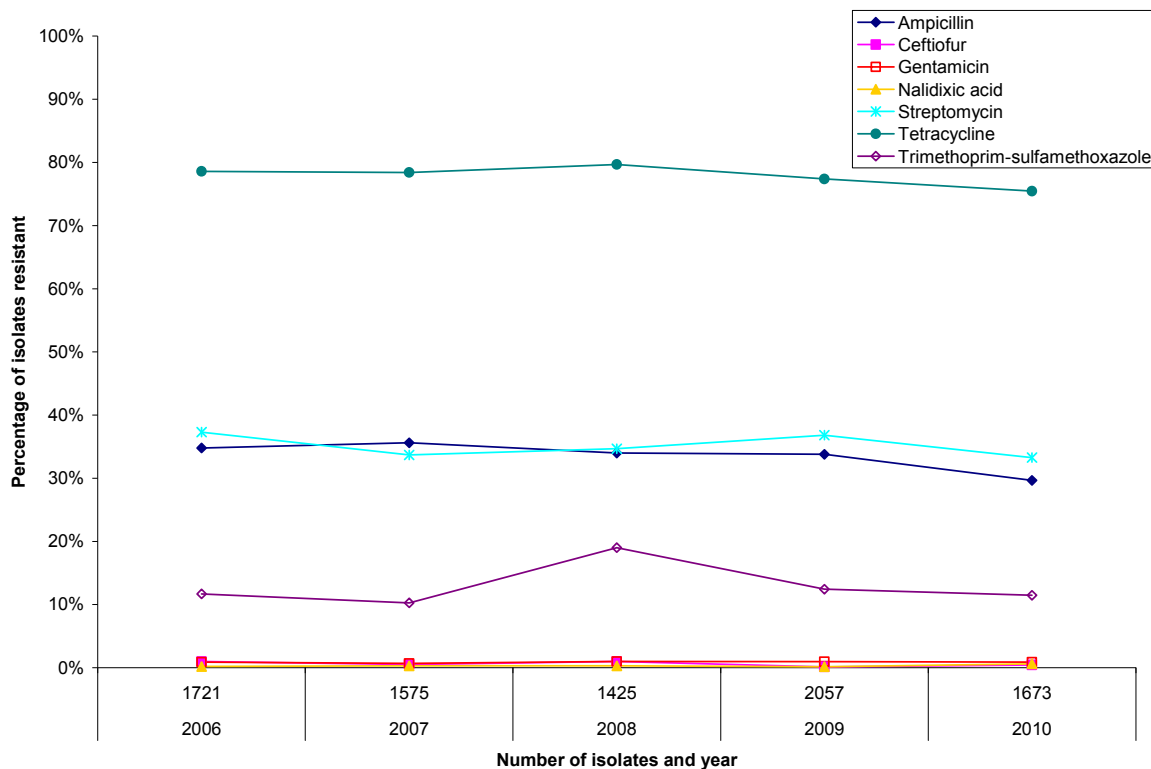
(n = 1,673)¹

Figure 32. Resistance to antimicrobials in *Escherichia coli* isolates from pigs; Farm Surveillance, 2010.



¹ Up to 3 generic *E. coli* isolates per positive sample were kept for analysis. The expected number of total isolates was 1,698 (566 x 3) but 25 isolates could not be cultured after freezing, leaving 1,673 available for antimicrobial susceptibility testing. The number of isolates recovered through *Farm Surveillance* was much higher than through other surveillance components. The reason for collecting a larger number of isolates in *Farm Surveillance* is to ensure adequate power to investigate the association between antimicrobial resistance and antimicrobial use.

Figure 33. Temporal variation in resistance to selected antimicrobials in *Escherichia coli* isolates from pigs; *Farm Surveillance, 2006–2010*.

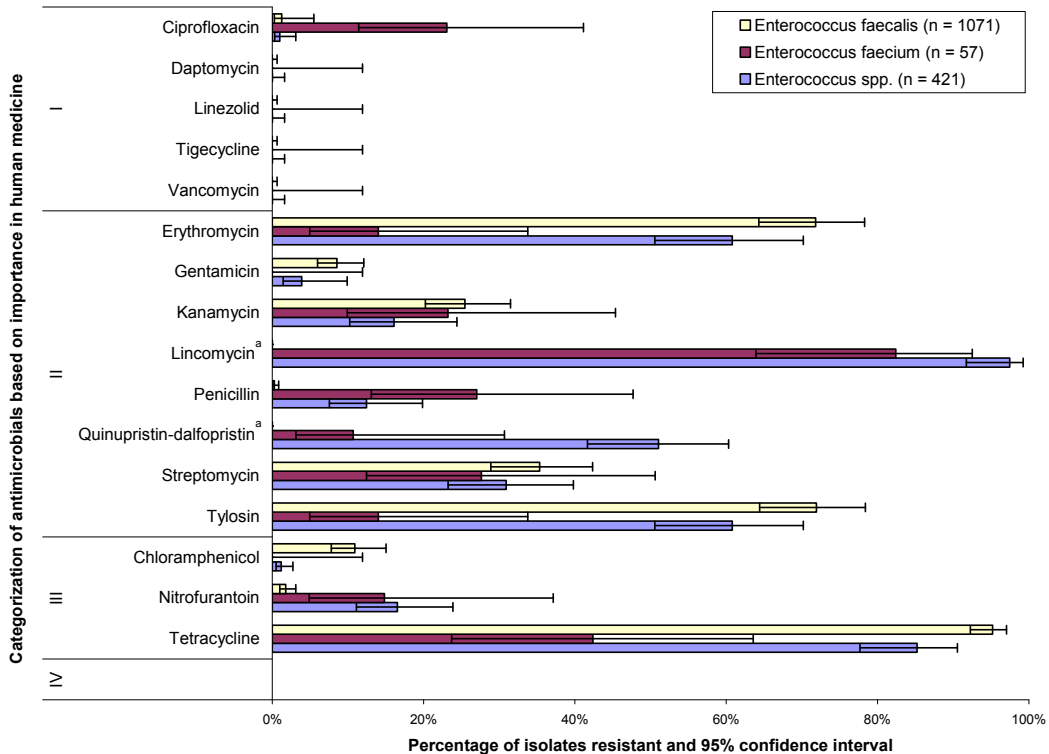


Enterococcus

Farm Surveillance

(n = 1,549)¹

Figure 34. Resistance to antimicrobials in *Enterococcus* isolates from pigs; *Farm Surveillance*, 2010.



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

¹ Up to 3 *Enterococcus* isolates per positive sample were kept for analysis. The expected number of total isolates was 1,635 (545 x 3) but 86 isolates could not be cultured after freezing, leaving 1,549 available for antimicrobial susceptibility testing. The number of isolates recovered through *Farm Surveillance* was much higher than through other surveillance components. The reason for collecting a larger number of isolates in *Farm Surveillance* is to ensure adequate power to investigate the association between antimicrobial resistance and antimicrobial use.

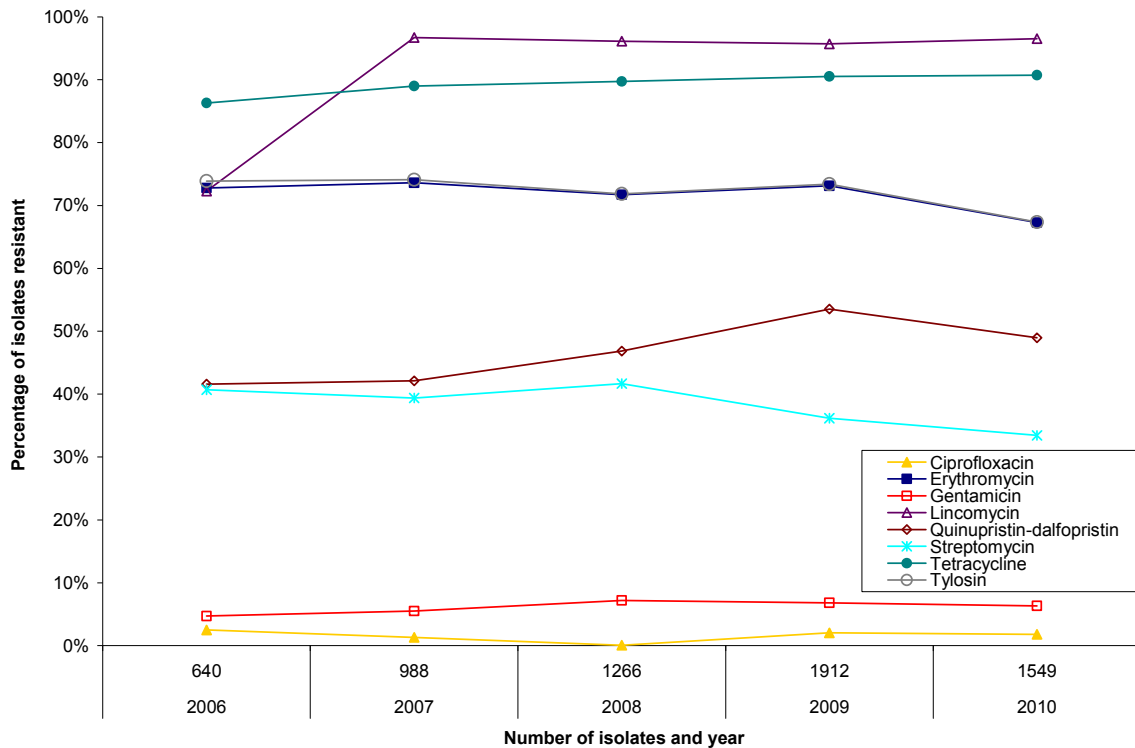
Table 22. Number of antimicrobial classes in resistance patterns of *Enterococcus* isolates from pigs; *Farm Surveillance*, 2010.

Species	Number (%) of isolates	Number of isolates resistant by antimicrobial class and antimicrobial																				
		Number of isolates by number of antimicrobial classes in the resistance pattern					Aminoglycosides		Glycopeptides	Glycylcyclines	Lincomides	Lipopeptides	Macrolides		Nitrofurans	Oxazolidinones	Penicillins	Phenicolis	Quinolones	Streptogramins	Tetracyclines	
		0	1	2-5	6-9	10-13	GEN	KAN	STR	VAN	TIG	LIN ^a	DAP	ERY	TYL	NIT	LNZ	PEN	CHL	CIP	QDA ^a	TET
<i>Enterococcus faecalis</i>	1,071 (69.1)	45	213	813		85	261	374						788	789	17		3	113	11		1019
<i>Enterococcus</i> spp.	421 (27.2)	11	46	317	47	13	60	115			408			260	260	62		60	5	4	216	353
<i>Enterococcus faecium</i>	57 (3.7)	4	19	28	6		15	20			48			10	10	8		19		11	7	31
Total	1,549 (100)	60	278	1,158	53	98	336	509			456			1,058	1,059	87		82	118	26	223	1,403

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

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

Figure 35. Temporal variation in resistance to selected antimicrobials in *Enterococcus* isolates from pigs; *Farm Surveillance*, 2006–2010.



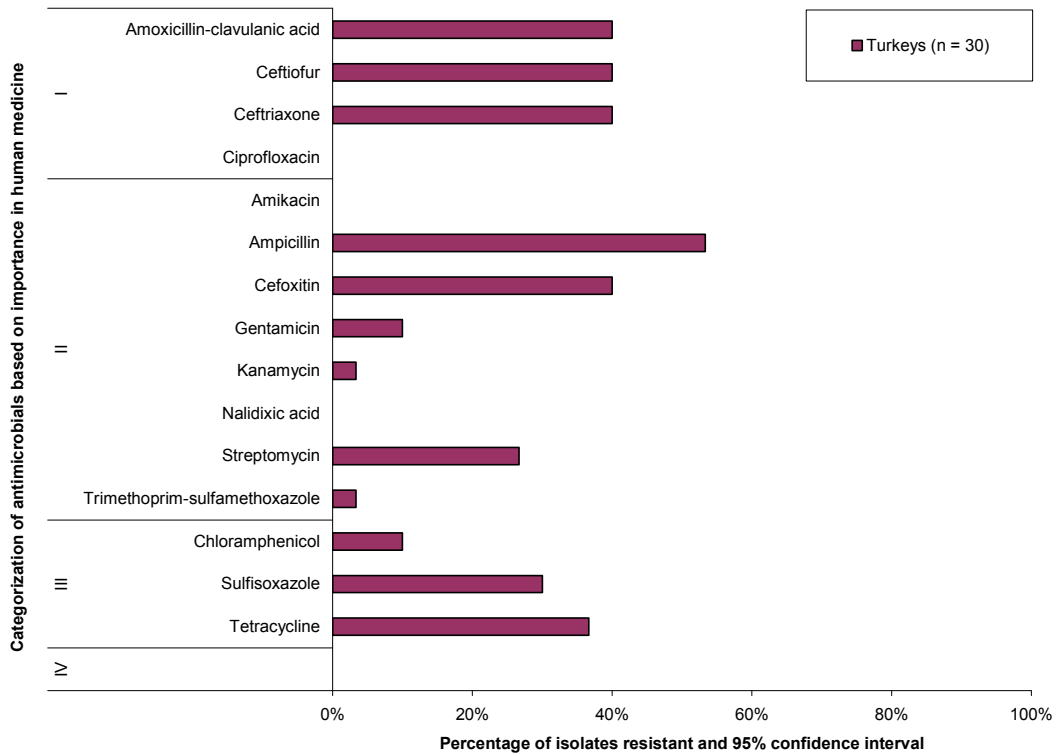
Turkeys

Salmonella

Surveillance of Animal Clinical Isolates

(n = 30)

Figure 36. Resistance to antimicrobials in *Salmonella* isolates from turkeys; Surveillance of Animal Clinical Isolates, 2010.



Confidence intervals are not displayed for animal clinical data because samples were not obtained randomly and may not represent independent observations.

Table 23. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from turkeys; *Surveillance of Animal Clinical Isolates, 2010.*

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern					Number of isolates resistant by antimicrobial class and antimicrobial															
		0	1	2-3	4-5	6	Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
							AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET	
Agona	7 (23.3)	1	3	1	2				2	5	5	5	5	5	3	1	2				3	
Senftenberg	5 (16.7)		3	2			2		2	4	4	4	4	4	1							
Heidelberg	4 (13.3)	2	2																			2
Hadar	3 (10.0)		1	2					2													3
Saintpaul	2 (6.7)		1		1				1	2	1	1	1	1	1		1					1
Schwarzengrund	2 (6.7)	2																				
Typhimurium	2 (6.7)		2							2	2	2	2	2								
Typhimurium var. 5-	2 (6.7)			2						2							2					
Johannesburg	1 (3.3)			1													1					1
Montevideo	1 (3.3)			1				1	1	1							1					1
Muenster	1 (3.3)		1							1												
Total	30 (100)	5	13	9	3		3	1	8	16	12	12	12	12	9	1	3				11	

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

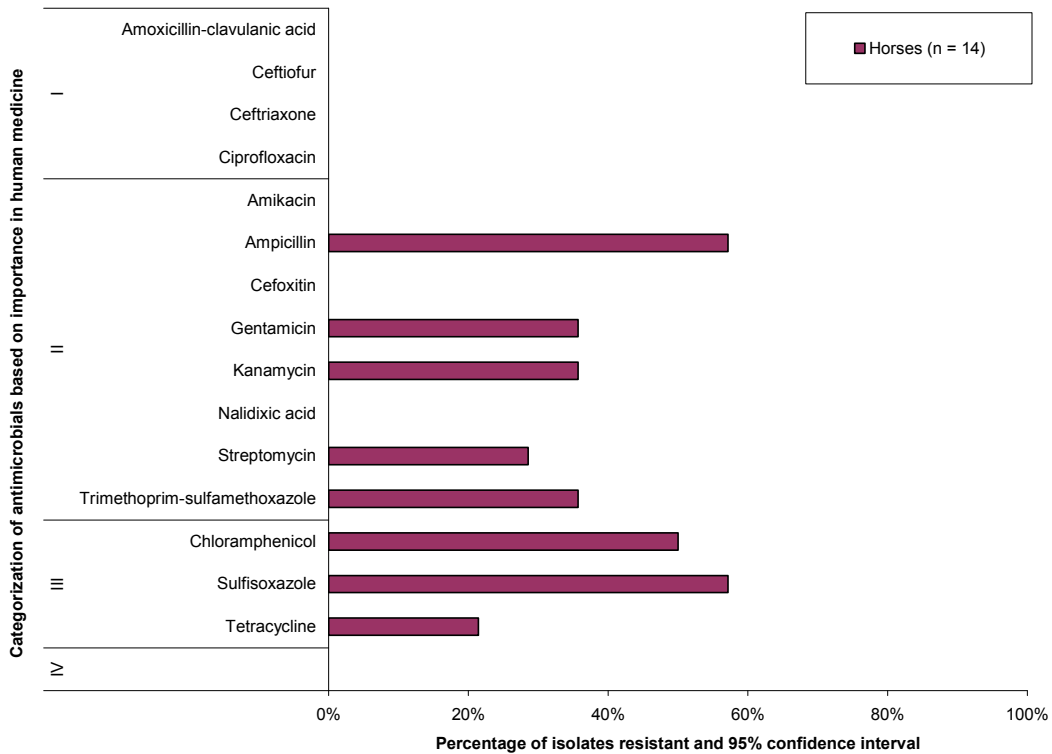
Horses

Salmonella

Surveillance of Animal Clinical Isolates

(n = 14)

Figure 37. Resistance to antimicrobials in *Salmonella* isolates from horses; *Surveillance of Animal Clinical Isolates*, 2010.



Confidence intervals are not displayed for animal clinical data because samples were not obtained randomly and may not represent independent observations.

Table 24. Number of antimicrobial classes in resistance patterns of *Salmonella* isolates from horses; *Surveillance of Animal Clinical Isolates, 2010*.

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern				Number of isolates resistant by antimicrobial class and antimicrobial															
						Aminoglycosides				β-lactams					Folate pathway inhibitors		Phenicols		Quinolones		Tetracyclines
		0	1	2-3	4-5	6	AMK	GEN	KAN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	CHL	CIP	NAL	TET
Heidelberg	5 (35.7)			1	4			5	5	1	5					5	5	4			
Typhimurium	3 (21.4)				3					3	3					3		3			
Muenster	2 (14.3)		2																		
Braenderup	1 (7.1)		1																		
Enteritidis	1 (7.1)		1																		
Oranienburg	1 (7.1)		1																		
Saintpaul	1 (7.1)		1																		
Total	14 (100)	6		1	7			5	5	4	8				8	5	7				3

Red, blue, and black numbers indicate isolates resistant to antimicrobials in Categories I, II, and III of importance in human medicine, respectively.

Feed and Feed Ingredients

Salmonella

(n = 31)

Results from the surveillance component *Feed and Feed Ingredients* were not presented in this report because the 31 *Salmonella* isolates recovered were not resistant to any of the antimicrobials tested.

Appendix

Recovery Rates

Table A.1. Bacterial recovery rates of samples collected through the CIPARS agri-food components, 2002-2010.

CIPARS													
Component/ Animal species	Province	Year	Percentage (%) of isolates recovered and number of isolates recovered/number of samples submitted										
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>							
Retail Meat Surveillance													
Beef	British Columbia	2005	93%	27/29									
		2007	79%	49/62									
		2008	77%	88/115									
		2009	71%	79/112									
		2010	51%	64/125									
	Saskatchewan	2005	79%	120/151									
		2006	76%	123/161									
		2007	78%	118/151									
		2008	76%	134/177									
		2009	83%	135/163									
	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								
			2008	78%	185/236								
			2009	79%	195/248								
			2010	69%	123/177								
			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											
2008	59%	126/214											
2009	54%	108/201											
Maritimes		2004	67%	16/24									
		2007	52%	16/31									
		2008	70%	39/56									
		2009	69%	137/200									
		2010	69%	126/183									

Results in the grey-shaded areas indicate samples that were not cultured, or isolates that were recovered but not submitted as part of CIPARS core surveillance antimicrobial susceptibility testing activities.

Human and animal clinical *Salmonella* data were not presented as the information on the number of samples cultured and isolates recovered was unavailable to CIPARS.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

Table A.1 (continued). Bacterial recovery rates of samples collected through the CIPARS agri-food components, 2002-2010.

CIPARS											
Component/ Animal species	Province	Year	Percentage (%) of isolates recovered and number of isolates recovered/number of samples submitted								
			<i>Escherichia coli</i>	<i>Salmonella</i>		<i>Campylobacter</i>		<i>Enterococcus</i>			
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	
		2008	90%	70/78	32%	47/145	34%	50/145	100%	78/78	
		2009	95%	70/74	40%	59/146	53%	78/146	97%	72/74	
		2010	89%	75/84	34%	56/166	42%	70/166			
	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	
		2008	99%	91/92	40%	64/161	25%	41/161	100%	92/92	
		2009	98%	90/92	47%	71/150	32%	48/150	100%	92/92	
	Ontario	2010	90%	71/79	32%	42/132	28%	37/132			
		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	
		2008	96%	150/156	45%	139/311	39%	121/311	99%	154/156	
		2009	95%	155/164	43%	142/328	31%	101/328	100%	164/164	
		2010	86%	100/116	39%	90/232	28%	64/232			
		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	
	2008		91%	131/144	42%	120/287	19%	54/287	100%	144/144	
	2009		94%	126/134	39%	105/267	20%	52/266	99%	132/134	
	2010		93%	138/148	39%	116/296	21%	63/296			
	Maritimes		2004	100%	13/13	4%	1/25	40%	10/25	100%	13/13
			2007 ^b	91%	29/32	22% ^a	7/32				
		2008 ^b	68%	38/56	22%	12/56					
		2009 ^b	94%	187/199	49%	97/199	29%	57/199			
		2010	93%	176/190	41%	77/190	37%	70/190			
	Pork	British Columbia	2005	31%	10/32						
			2007	29%	23/79	1%	1/79				
			2008	30%	44/148	2%	3/148				
			2009	26%	38/145	1%	2/145				
			2010	19%	31/166	1%	2/167				
		Saskatchewan	2005	30%	48/162						
			2006	30%	49/165	2%	3/134				
			2007	25%	38/154	2%	3/154				
2008			23%	41/176	1%	1/176					
2009			18%	29/164	0%	0/164					
2010			12%	17/142	1%	1/142					
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					
		2008	50%	155/312	2%	7/310					
		2009	41%	136/328	2%	8/327					
		2010	38%	84/224	0%	0/224					
		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					
2008			21%	60/287	2%	5/286					
2009			15%	41/268	1%	3/268					
2010			16%	47/296	1%	4/296					
Maritimes			2004	58%	14/24						
			2007	39%	13/31	3%	1/30				
		2008	30%	17/56	2%	1/56					
	2009	41%	82/200	3%	5/199						
	2010	39%	74/190	4%	8/190						

Results in the grey-shaded areas indicate samples that were not cultured, or isolates that were recovered but not submitted as part of CIPARS core surveillance antimicrobial susceptibility testing activities.

The Maritimes region includes New Brunswick, Nova Scotia, and Prince Edward Island.

^a Enhancement to the *Salmonella* recovery method yielded higher recovery rates from retail chicken in 2007 than in prior years.

^b Recovery results are not presented for *Campylobacter* in 2007 and 2008 as well as for *Enterococcus* in 2007, 2008 and 2009 due to concerns regarding harmonization of laboratory methods.

Table A.1 (continued). Bacterial recovery rates of samples collected through the CIPARS agri-food components, 2002-2010.

Composante du PICRA/ Espèce	Province	Année	Pourcentage (%) d'isolats détectés et le nombre d'isolats détectés/nombre d'échantillons soumis			
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>
Surveillance en abattoir						
Bovins de boucherie	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
	2008	97%	176/182			71% ^c 129/182
	2009	94%	119/126			68% 86/126
	2010	97% ^d	77/79			53% ^d 37/70
	Poulets	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%	200/1,103	
2006		100%	166/166	23%	187/824	
2007		99%	180/181	25%	204/808	
2008		99%	170/171	28%	234/851	
2009		100%	171/171	27%	230/851	
2010		99%	119/120	24%	142/599	19% 111/599
Porcs		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	
	2008	100%	150/150	44%	151/340	
	2009	98%	160/163	45%	147/327	
	2010	98%	199/203	44%	182/410	
	Surveillance à la ferme					
Porcs	2006	99%	459/462	20%	94/462	81% 374/462
	2007	100%	612/612	21%	136/612	81% 495/612
	2008	99%	481/486	13%	61/486	92% 448/486
	2009	99%	695/698	18%	124/698	97% 680/698
	2010	99%	566/569	18%	101/569	96% 545/569

Results in the grey-shaded areas indicate samples that were not cultured, or isolates that were recovered but not submitted as part of CIPARS core surveillance antimicrobial susceptibility testing activities.

^c Implementation of a new *Campylobacter* recovery method in 2008 in abattoir beef cattle isolates.

^d In 2010, the number of samples received from abattoir beef cattle was much lower than anticipated due to a 55% drop in submissions related to unavoidable operational issues at 2 major participating abattoirs.

Antimicrobial Susceptibility Breakpoints

Table A.2. Breakpoints in antimicrobial susceptibility of *Salmonella* and *Escherichia coli* isolates; CMV1AGNF plate, 2010.

Antimicrobial	Range tested ($\mu\text{g/mL}$)	Breakpoints ^a ($\mu\text{g/mL}$)		
		S	I	R
Amoxicillin-clavulanic acid	1.0/0.5 – 32/16	$\leq 8/4$	16/8	$\geq 32/16$
I Ceftiofur	0.12 – 8	≤ 2	4	≥ 8
Ceftriaxone	0.25 – 64	≤ 1	2	≥ 4
Ciprofloxacin	0.015 – 4	≤ 1	2	≥ 4
Amikacin	0.5 – 32	≤ 16	32	≥ 64
Ampicillin	1 – 32	≤ 8	16	≥ 32
Cefoxitin	0.5 – 32	≤ 8	16	≥ 32
II Gentamicin	0.25 – 16	≤ 4	8	≥ 16
Kanamycin	8 – 64	≤ 16	32	≥ 64
Nalidixic acid	0.5 – 32	≤ 16	N/A	≥ 32
Streptomycin ^b	32 – 64	≤ 32	N/A	≥ 64
Trimethoprim-sulfamethoxazole	0.12/2.38 – 4/76	$\leq 2/38$	N/A	$\geq 4/76$
Chloramphenicol	2 – 32	≤ 8	16	≥ 32
III Sulfisoxazole	16 – 512	≤ 256	N/A	≥ 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. N/A = Not applicable.

^a CLSI M100-S21.

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

Appendix – Antimicrobial Susceptibility Breakpoints

Table A.3. Breakpoints in antimicrobial susceptibility of *Enterococcus* isolates; CMV3AGPF plate, 2010.

Antimicrobial	Range tested ($\mu\text{g/mL}$)	Breakpoints ^a ($\mu\text{g/mL}$)		
		S	I	R
Ciprofloxacin	0.12 – 4	≤ 1	2	≥ 4
Daptomycin ^b	0.25 – 16	≤ 4	N/A	N/A
I Linezolid	0.5 – 8	≤ 2	4	≥ 8
Tigecycline ^c	0.015 – 0.5	≤ 0.25	0.5	≥ 1
Vancomycin	0.25 – 32	≤ 4	8 – 16	≥ 32
Erythromycin	0.25 – 8	≤ 0.5	1 – 4	≥ 8
Gentamicin (high-level)	128 – 1,024	≤ 500	N/A	> 500
Kanamycin (high-level) ^b	128 – 1,024	≤ 512	N/A	$\geq 1,024$
II Lincomycin ^b	1 – 8	≤ 2	4	≥ 8
Penicillin	0.25 – 16	≤ 8	N/A	≥ 16
Quinupristin-dalfopristin	0.5 – 32	≤ 1	2	≥ 4
Streptomycin (high-level) ^b	512 – 2,048	$\leq 1,000$	N/A	$> 1,000$
Tylosin ^b	0.25 – 32	≤ 8	16	≥ 32
Chloramphenicol	2 – 32	≤ 8	16	≥ 32
III Nitrofurantoin	2 – 64	≤ 32	64	≥ 128
Tetracycline	1 – 32	≤ 4	8	≥ 16
IV				

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. N/A = Not applicable.

^a CLSI M100-S21 Table 2D. M7-A8-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 minimal 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 the CLSI for tigecycline.

Table A.4. Breakpoints in antimicrobial susceptibility of *Campylobacter* isolates; CAMPY plate, 2010.

Antimicrobial	Range tested ($\mu\text{g/mL}$)	Breakpoints ^a ($\mu\text{g/mL}$)		
		S	I	R
I Ciprofloxacin	0.015 – 64	≤ 1	2	≥ 4
Telithromycin ^b	0.015 – 8	≤ 4	8	≥ 16
Azithromycin ^b	0.015 – 64	≤ 2	4	≥ 8
Clindamycin ^b	0.03 – 16	≤ 2	4	≥ 8
II 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 ^c	0.03 – 64	≤ 4	N/A	N/A
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. N/A = Not applicable.

^a CLSI M45-A2.

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

^c For florfenicol, only a susceptible breakpoint has been established. In this report, we therefore only report the proportion of isolates non-susceptible.

Abbreviations

Antimicrobials

AMC Amoxicillin-clavulanic acid	NAL Nalidixic acid
AMK Amikacin	NIT Nitrofurantoin
AMP Ampicillin	PEN Penicillin
AZM Azithromycin	QDA Quinupristin-dalfopristin
CHL Chloramphenicol	SSS Sulfisoxazole
CIP Ciprofloxacin	STR Streptomycin
CLI Clindamycin	SXT Trimethoprim-sulfamethoxazole
CRO Ceftriaxone	TEL Telithromycin
DAP Daptomycin	TET Tetracycline
ERY Erythromycin	TIG Tigecycline
FLR Florfenicol	TIO Ceftiofur
FOX Cefoxitin	TYL Tylosin
GEN Gentamicin	VAN Vancomycin
KAN Kanamycin	
LIN Lincomycin	
LNZ Linezolid	

Canadian Provinces/Territories and Regions

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