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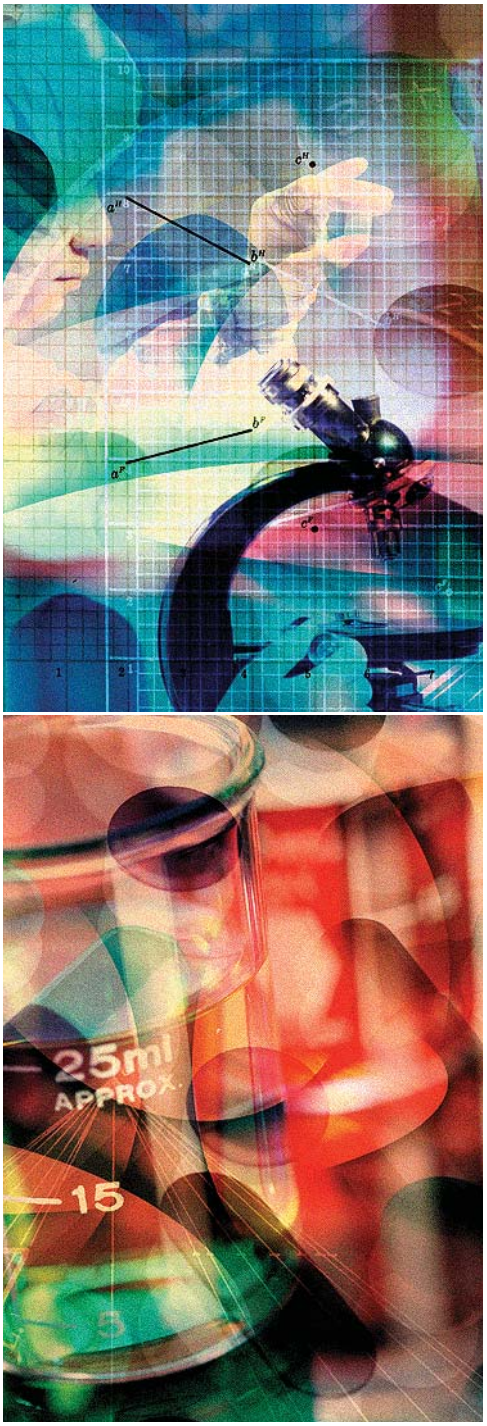

Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)

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

2006

Canada

Healthy Canadians and communities in a healthier world

Public Health Agency of Canada

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2006

Authors and Participants of CIPARS 2006

These acknowledgements are meant to identify the numerous individuals and organizations that have contributed to the success of CIPARS. We are grateful to everyone who has helped make this program a success.

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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 (Figure 1). This information supports the creation and evaluation of policies to contain antimicrobial resistance and better manage antimicrobial use in human medicine, as well as in the veterinary and agricultural sectors. The 2006 CIPARS Annual Report presents human and animal antimicrobial use data, as well as antimicrobial resistance findings from human clinical *Salmonella* isolates, food-animal isolates (collected from farms and abattoir sites), retail meat isolates, and *Salmonella* isolates from clinical veterinary samples.

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

From 2002 to 2006, ceftiofur resistance was observed in numerous *Salmonella* serovars recovered from human cases, food-animals and meat samples. Ceftiofur resistance was most frequently found in chicken isolates, especially *Salmonella* Heidelberg. The emergence of ceftiofur 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 human and animal species, strengthens the need for prudent antimicrobial use across Canada and in all species.

Since 2003, S. Typhi and S. Paratyphi, human serovars that are associated with foreign travel, have shown rising levels of ciprofloxacin resistance. The presence of ciprofloxacin resistance in serovars more traditionally identified as being domestically acquired such as *S.* Typhimurium, *S.* Newport, *S.* Enteritidis, and *S.* Heidelberg is also of concern, as is the rising quantity of oral fluoroquinolones dispensed by retail pharmacies since 2000. Among food-animals, quinolone resistance has generally been observed in less than one percent of the bacteria tested, except in retail chicken *Campylobacter* isolates where approximately 3% of isolates have been quinolone resistant since 2003.

Vancomycin resistance in human *Enterococcus* infections is increasingly observed world-wide and in Canada, particularly in hospital settings. In Europe, vancomycin resistance in food-animals was associated with the use of the growth promoter avoparcin which was subsequently banned from use in food-animals in Denmark in 1995 and in all of the European Union in 1997. Avoparcin has never been approved for use in food-animals in North America. CIPARS has tested 1465 retail chicken *Enterococcus* isolates since 2003 and has detected no vancomycin resistance. Vancomycin resistance was also not detected in *Enterococcus* isolates from retail pork (n=99) and beef (n=100) recovered in 2003, retail turkey strains (n=16) recovered in 2005, or in 531 *Enterococcus* isolates from swine farms recovered since 2005. To date there is no evidence that food-animals are a source of human vancomycin-resistant *Enterococcus* strains in Canada.

Conclusion and Future Plans

CIPARS is continually evolving to better address its mandate. In 2006 a pilot study examining antimicrobial resistance in human *Campylobacter* isolates from Saskatchewan was conducted. *Campylobacter* in beef cattle at slaughter was added to the *Abattoir Surveillance* component to monitor resistance to quinolones following the approval of enrofloxacin and danofloxacin for beef cattle use. Retail sampling began in British Columbia and the Atlantic Provinces in 2006 and at the end of 2008 respectively. In collaboration with several other organizations, CIPARS initiated a national *On-Farm Swine Sentinel Surveillance* component in 2006 to provide estimates of antimicrobial use and antimicrobial resistance at the farm level. As well, a pilot project was initiated in Alberta beef feedlots in 2006 with the desire to expand to other major beef cattle producing provinces. CIPARS is continuing to negotiate with the chicken industry to establish an on-farm surveillance capacity in that sector.

Table 1. Summary of antimicrobial resistance surveillance findings across human and agri-food isolates, 2006.

Species	Bacterial species	Resistance to one or more antimicrobials	Resistance to five or more antimicrobials	Resistance to category I[1] antimicrobials	Resistance to NAL and/or reduced susceptibility to CRO	Number of different resistance patterns/ number of resistant isolates
		Number (%) of resistant isolates				
Surveillance of Human Clinical Isolates						
Human	*Salmonella*	1116/3205 (35%)	261/3205 (8%)	AMC: 116/3205 (4%) TIO: 112/3205 (3%) CRO: 5/3205 (<1%) CIP: 2/3205 (<1%)	CRO: 92/3205 (3%) NAL: 415/3205 (13%)	129/1116
Abattoir Surveillance						
Beef Cattle	*E. coli*	51/150 (34%)	1/150 (1%)			12/51
	Campylobacter	60/105 (57%)			NAL: 9/105 (9%)	3/60
Swine	*E. coli*	102/115 (89%)	15/115 (13%)		NAL: 1/115 (<1%)	37/102
	Salmonella	82/145 (57%)	23/145 (16%)	AMC: 1/145 (<1%) TIO: 1/145 (<1%)	CRO: 1/145 (<1%)	30/82
Chickens	*E. coli*	118/166 (71%)	39/166 (23%)	AMC: 44/166 (27%) TIO: 35/166 (21%)	CRO: 17/166 (10%) NAL: 5/166 (3%)	57/118
	Salmonella	99/187 (53%)	4/187 (2%)	AMC: 18/187 (10%) TIO: 18/187 (10%)	CRO: 14/187 (7%)	18/99
Retail Meat Surveillance						
Beef	*E. coli*	69/421 (16%)	6/421 (1%)	AMC: 2/421 (<1%) TIO: 1/421 (<1%)	NAL: 1/421 (<1%)	19/69
Pork	*E. coli*	138/288 (48%)	15/288 (5%)	AMC: 2/288 (<1%) TIO: 1/288 (<1%)		38/138
Chicken	*E. coli*	250/372 (67%)	48/372 (13%)	AMC: 63/372 (17%) TIO: 47/372 (13%)	CRO: 19/372 (5%) NAL: 9/372 (2%)	67/250
	Salmonella	44/94 (47%)	2/94 (2%)	AMC: 9/94 (10%) TIO: 9/94 (10%)	CRO: 6/94 (6%)	12/44
	Campylobacter	145/255 (57%)		CIP: 6/255 (2%)	NAL: 6/255 (2%)	9/145
	Enterococcus	358/382 (94%)	88/382 (23%)	CIP: 4/382 (1%) QDA: 11/20[2] (55%)	N/A	44/358
Surveillance of Animal Clinical Isolates						
Bovine	*Salmonella*	42/152 (28%)	30/152 (20%)	AMC: 11/152 (7%) TIO: 11/152 (7%) CRO: 1/152 (<1%)	CRO: 10/152 (7%)	19/42
Swine	*Salmonella*	154/204 (75%)	77/204 (38%)	AMC: 8/204 (4%) TIO: 7/204 (3%)	CRO: 6/204 (3%)	37/154
Chicken	*Salmonella*	24/115 (21%)	3/115 (3%)	AMC: 6/115 (5%) TIO: 6/115 (5%)	CRO: 3/115 (3%)	13/24
Turkeys	*Salmonella*	41/49 (84%)	17/49 (35%)	AMC: 19/49 (39%) TIO: 19/49 (39%) CRO: 6/49 (12%)	CRO: 10/49 (20%)	17/41
On-Farm Surveillance						
Swine	*E. coli*	1905/2197 (87%)	328/2197 (15%)	AMC:35/2197 (2%) TIO: 22/2197 (1%) CIP: 1/2197 (<1%)	CRO:11/2197 (<1%) NAL: 4/2197 (<1%)	90/1905
	Salmonella	62/94 (66%)	14/94 (15%)	AMC: 1/94 (1%) TIO: 1/94 (1%)	CRO: 1/94 (1%)	20/62
	Enterococcus	835/867 (96%)	369/867 (43%)	CIP: 20/867 (2%) QDA:94/225 (42%)	N/A	105/835

Note: Blank cells represent values equal to zero (0%). Abbreviations: See full names of antimicrobials in Appendix C.1. N/A=Not applicable.

[1] Categorization of Antimicrobial Drugs Based on their Importance in Human Medicine (Appendix A.1)

[2] *Enterococcus* species other than *E. faecalis* (n= 362).

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Preamble

About CIPARS

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) was created in 2002. CIPARS 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 to control antimicrobial use in hospitals, communities, and animal production and thus, prolong the effectiveness of these drugs, and (ii) the identification of appropriate measures to contain the emergence and spread of resistant bacteria between animals, food, and people. This publication represents the fifth annual CIPARS report being 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 the assessment of the public health impact of antimicrobials used in humans and the agricultural sectors
- To provide data that permits accurate comparisons with other countries that use similar surveillance systems

CIPARS 2006 Activities

For antimicrobial resistance in 2006, CIPARS operated three active surveillance components and two passive surveillance components (Figure 1):

1. *Abattoir Surveillance* which involved sample collection and analysis of generic *Escherichia coli* and *Salmonella* from the cæcal contents of healthy chickens and finished pigs and of *E. coli* and *Campylobacter* from healthy beef cattle across Canada.

2. Retail Meat Surveillance which involved the collection and analysis of generic *E. coli, Salmonella, Campylobacter*, and *Enterococcus* from retail chicken meat and of generic *E. coli* in beef and pork meat in British Columbia, Saskatchewan, Ontario, and Québec. *Salmonella* was also recovered from pork samples but due to its low prevalence in meat, no antimicrobial susceptibility findings are presented in this report on the few recovered isolates.

3. *On-Farm Surveillance* was implemented in January 2006 in swine herds across the five major pork producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). This involved the participation of the Alberta and Saskatchewan's Ministries of Agriculture Food and Rural Development. This surveillance component used a sentinel farm framework collecting pooled swine fecal samples and providing *E. coli, Enterococcus*, and *Salmonella* isolates for antimicrobial susceptibility testing[4] and also included the collection of drug use data.

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

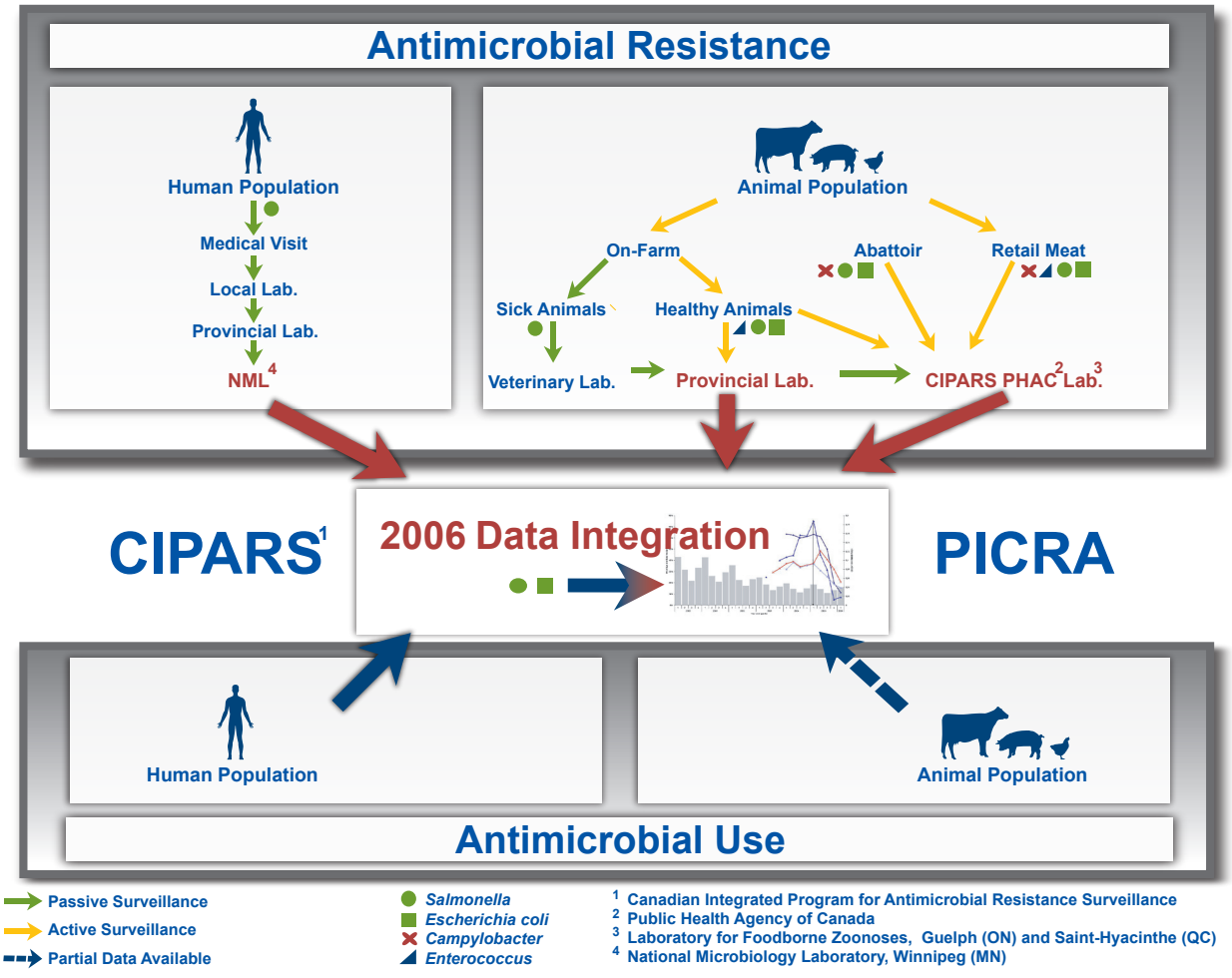
5. *Surveillance of Animal Clinical Isolates* which involved passive surveillance of clinical *Salmonella* isolates from multiple provinces across Canada and involved the participation of the Laboratoire d'expertise en pathologie animale du Québec for the serotyping of clinical *Salmonella* isolates from the province of Québec. Specimens are originally submitted by veterinarians or producers to local or provincial laboratories and may additionally include environmental samples or samples from non-diseased animals from the same herd.

[4] Administered and coordinated by the Laboratory for Foodborne Zoonoses, Public Health Agency of Canada.

CIPARS focuses particularly on resistance to antimicrobial classes of Very High importance in Human Medicine (Category I) such as the extended spectrum ß-lactam inhibitor combination (e.g. amoxicillin-clavulanic acid), newer generation cephalosporins (e.g. ceftiofur, ceftriaxone), and fluoroquinolones (e.g. ciprofloxacin). Resistance to the quinolone nalidixic acid resistance is also highlighted because of cross-resistance with fluoroquinolones.

Human antimicrobial use data obtained from Intercontinental Medical Statistics Health continues to be reported, and unique to the 2006 report is the inclusion of animal antimicrobial distribution data which has been provided by the Canadian Animal Health Institute (CAHI).

Figure 1. Diagram of CIPARS surveillance components in 2006.



What's new in the 2006 Report

Changes to CIPARS design

- Antimicrobial resistance (AMR) results from the *On-Farm Surveillance* component are presented for the first time in this Annual Report. Antimicrobial use data were collected using sampling day questionnaires and CQA® forms[5]. Analysis of the 2006 antimicrobial use data is pending, and once completed this data will be provided in a subsequent report. The most relevant resistance findings are presented in this report, but additional

[5] http://www.cqa-aqc.ca/home_e.cfm

information will be available in the "On-Farm Swine 2006 Antimicrobial Resistance Supplemental Report". This report will be posted on the CIPARS website in 2009[6].
- *Abattoir surveillance of Campylobacter* from beef cattle started in late 2005. The results for the end of 2005 and 2006 are presented in this report.
- 2006 national animal antimicrobial distribution data provided by CAHI.

Methodological changes

- The ETest® diffusion methodology (AB Biodisk, Solna, Sweden) was replaced with the NARMS susceptibility panels (Sensititre™) for antimicrobial susceptibility testing of *Campylobacter*. By doing so, **chloramphenicol** was replaced by **florfenicol** and **telithromycin** was added to the panel.
- The abbreviation used for sulfisoxazole (SMX) in the 2005 report is now changed for the abbreviation 'SSS' which can stand for the antimicrobial sulfamethoxazole prior to 2005 or sulfisoxazole in 2005 and subsequent years.
- For the *Enterococcus* isolates collected from *On-farm Surveillance* in Alberta and Saskatchewan, the antimicrobial **tigecycline** was additionally tested but **bacitracin** was not included on these test panels.

Particular attention given to selected antimicrobials/patterns

Note: Intermediate susceptibility refers to the Clinical and Laboratory Standards Institute (CLSI) guidelines for their intermediate category, with the exception of ciprofloxacin where the range is expanded beyond the CLSI guidelines and we have designated this as 'reduced susceptibility'. Please see further details below.

- **Ciprofloxacin:** Is a fluoroquinolone antimicrobial classified as a Category I drug of Very High Importance in Human Medicine (Appendix A.1). Because of reports of treatment failure in humans, there is a debate around the appropriateness of the ciprofloxacin resistance breakpoint used for *Salmonella* isolates (Crump et al 2003). The current CLSI resistance breakpoint for this antimicrobial agent and adopted in this report is ≥4 µg/ml. The Danish Programme for surveillance of antimicrobial resistance in bacteria from livestock, foods, and humans (DANMAP) however 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 significance of this molecule and in order to show results in a format comparable to DANMAP, we have introduced in this report the term "reduced susceptibility" which designates ciprofloxacin MICs from 0.125 to 2µg/mL. To obtain resistance results comparable to DANMAP figures, the percentage of isolates from this report showing reduced susceptibility must be added to the percentage of isolates resistant to ciprofloxacin.

- **Nalidixic acid:** Is a quinolone antimicrobial classified as a Category II drug of High Importance in Human Medicine (Appendix A.1). Fluoroquinolone-susceptible strains of *Salmonella* that are 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. Physicians should be aware that bacteria might not be eradicated by fluoroquinolone treatment when isolates are susceptible to fluoroquinolones but resistant to nalidixic acid (CLSI M100-S16).

- **Ceftriaxone:** Is a third-generation cephalosporin classified as a Category I drug of Very High Importance in Human Medicine (Appendix A.1). There is a correlation between intermediate susceptibility to ceftriaxone (intermediate susceptibility range for ceftriaxone is 16 to 32µg/mL according to CLSI guidelines) and possible clinical treatment failure, thus we highlight intermediate susceptibility to ceftriaxone in addition to resistance.

- **Ceftiofur:** Is a third-generation cephalosporin antimicrobial classified as a Category I drug of Very High Importance in Human Medicine (Appendix A.1) licensed for animal use only. The "breakpoint" for resistance to ceftiofur is lower than that for resistance to ceftriaxone (which is only licensed for use in humans). Resistance to ceftiofur will generally be associated with resistance to amoxicillin-clavulanic acid, cefoxitin, ampicillin (A2C-AMP), and intermediate susceptibility or resistance to ceftriaxone.

[6] http://www.phac-aspc.gc.ca/cipars-picra/pubs_e.html

- **Amoxicillin-clavulanic acid:** Is an extended spectrum ß-lactam inhibitor combination which is classified as a Category I drug of Very High Importance in Human Medicine (Appendix A.1). Resistance results related to this antimicrobial will only be highlighted for *E. coli* isolates, as this antimicrobial is not used for the treatment of salmonellosis in humans.

- **Telithromycin:** Is the first ketolide antimicrobial to enter clinical use and is a semi-synthetic erythromycin derivative which is classified as a Category I drug of Very High Importance in Human Medicine (Appendix A.1).

Additional Information

- Antimicrobial drugs are categorized based on their importance in human medicine (Veterinary Drugs Directorate, categorization revised in November 2006; Appendix A.1). Antimicrobials are generally listed first according to this classification and then alphabetically.
- Analysis of temporal trends in resistance rates involved comparing changes in the prevalence of resistance between the years 2003 and 2006, unless otherwise specified in the text
- The p value used in this report was $p<0.05$.
- The terms “decrease” or “increase” are only used when the decrease or increase is statistically significant.
- The term ‘non susceptible to’ will be used instead of ‘resistant to’ when referring to daptomycin and florfenicol AMR results because these antimicrobials do not have any defined resistance breakpoints (Appendix B).

Section One – Antimicrobial Resistance

Antimicrobial Resistance in Human Clinical Isolates

Throughout 2006, the Provincial Public Health Laboratories forwarded a total of 3205 *Salmonella* isolates (171 serovars) to the National Microbiology Laboratory (NML) for phage typing and susceptibility testing (see Appendix A.2). The information available in the CIPARS database regarding outbreak related isolates was considered to be too incomplete to account for outbreaks in the analysis.

Results are provided for the three most frequently isolated serovars in Canada (*S.* Enteritidis, *S.* Heidelberg, and *S.* Typhimurium). *Salmonella* Newport also receives attention because of past outbreaks involving multidrug resistant strains. *Salmonella* Typhi, *S.* Paratyphi A and *S.* Paratyphi B[7], three serovars with no agri-food reservoirs, are also presented because they cause severe disease in humans[8].

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

We provide details on isolates recovered from blood and urine samples because they are more likely to be associated with an antimicrobial treatment as they are likely to be more invasive infections, though the drug use history of these cases was not available to us. It is important to note that these samples may have been submitted after therapeutic failure, which could potentially bias the resistance patterns.

At the end of this section, we highlight research conducted by the Alberta Provincial Public Health Laboratory in conjunction with CIPARS analysis that compared the susceptibility findings for *Salmonella* isolates from Alberta submitted during the first 15 days of the month (as per CIPARS sampling plan) versus those from the last 15 days of the month.

Salmonella Enteritidis

(n=710)

The provincial/territorial incidence rates of *S.* Enteritidis varied from 0 to 6.22 (median=3.34) cases per 100,000 inhabitant-years[9]. No cases were reported in the Yukon, Northwest Territories, or Nunavut. Among all *S.* Enteritidis isolates the most frequent phage types were PT 4 (25%, 176/710), PT 13 (20%, 142/710), PT 1 (13%, 95/710) and, PT 8 (13%, 95/710).Three percent (19/710) of the isolates were cultured from blood and 2% (13/710) of the isolates were cultured from urine samples (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results are presented in Table 2, Table 9, and Table 36 (Appendix B.1). Resistance to one or more antimicrobials was detected in 23% (172/710) of the isolates. Resistance to nalidixic acid was found in 20% of the isolates (141/710). No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or gentamicin. Resistance to ceftiofur was present in less than 1% (2/710) of the isolates. One of these two isolates had intermediate susceptibility to ceftriaxone. Reduced susceptibility to ciprofloxacin was found in 20% (143/710) of isolates.

AMR Patterns: The most frequent pattern was resistance to nalidixic acid alone (18%, 125/710). One isolate had the ACKSSuT pattern and one isolate had the A2C-AMP pattern. Resistance to five or more antimicrobials was detected in less than 1% (3/710) of the isolates. Most blood (18/19) and all the urine isolates were fully susceptible. The one resistant blood isolate had the AMP-NAL-TET resistance pattern.

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[7] Does not include S. Paratyphi B var. L (+) tartrate+, formely called S. Paratyphi var. Java. The biotype of S. Paratyphi B included here is tartrate (-) and is associated with more severe, typhoid-like fever. S. Paratyphi B var. L (+) tartrate + is commonly associated with gastroenteritis and since it also possesses an animal reservoir, it is included under "Other Serovars".

[8] PHAC, Material Safety Data Sheet – Infectious Substances, http://www.phac-aspc.gc.ca/msds-ftss/msds133e.html and http://www.phac-aspc.gc.ca/msds-ftss/msds134e.html.

[9] The number of laboratory confirmed cases/100,000 inhabitant-years in each province was calculated by dividing the total number of cases obtained by CIPARS in each province by the province's population (Stat. Can. Post-Censal population estimates based on data obtained from Statistics Canada, Demography Division), multiplied by 100,000. In BC, AB, ON, and QC where only isolates from the first 15 days are forwarded to CIPARS, the number of cases was multiplied by two to estimate the total number of cases obtained during the year.

Temporal Variations: See Figure 2. Resistance to one or more antimicrobials was 12% (76/614) in 2005 and has risen to 23% in 2006. This rise is mainly attributable to the increase of resistance to nalidixic acid. The prevalence of nalidixic acid resistance was significantly higher in 2006 compared to 2005 but was similar to the proportion of resistance in 2003 and 2004. The drop in nalidixic resistance observed in 2005 could be related to the emergence of the susceptible PT13 strains. Phage type 4 and PT 1 are the two main phage types associated with nalidixic acid resistance in S. Enteritidis since 2003. The increase in nalidixic resistance between 2005 and 2006 could be associated with a significant increase of PT 4 isolates reported in 2006 and a significant decrease of PT 13 isolates. New to 2006, is the presence of five PT 13 isolates with resistance to nalidixic acid. The prevalence of reduced susceptibility to ciprofloxacin was significantly higher in 2006 compared to 2005 (7%, 80/864), but similar to the proportion of resistance in 2003 (18%, 65/352) and 2004 (22%, 122/549). The five PT13 isolates with resistance to nalidixic acid mentioned above were also found to have reduced susceptibility to ciprofloxacin. While the incidence of S. Enteritidis has decreased between 2003 and 2006, the number of nalidixic acid resistant PT 1 varied from 40 isolates in 2003, 45 isolates in 2004, 28 isolates in 2005, to 50 isolates in 2006. There were 12 PT 4 nalidixic acid resistant isolates in 2003, 44 isolates in 2004, 10 isolates in 2005, and 47 isolates in 2006.

New to 2006, is the presence of five PT 13 human *S.* Enteritidis isolates with resistance to nalidixic acid and reduced susceptibility to ciprofloxacin.

Table 2. Individual antimicrobial drug resistance in human *Salmonella* Enteritidis isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

	Antimicrobial	BC N=71 n (%)	AB N=101 n (%)	SK N=34 n (%)	MB N=35 n (%)	ON N=298 n (%)	QC N=89 n (%)	NB N=35 n (%)	NS N=33 n (%)	PEI N=8 n (%)	NL N=6 n (%)	Canada[1] %
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)	1 (3)	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)	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 (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	3 (4)	6 (6)	2 (6)	1 (3)	6 (2)	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)	3
II	cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	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)	0 (0)	0
II	kanamycin	1 (1)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
II	nalidixic acid	16 (23)	20 (20)	8 (24)	8 (23)	54 (18)	13 (15)	8 (23)	14 (42)	2 (25)	0 (0)	20
II	streptomycin	2 (3)	1 (1)	1 (3)	0 (0)	4 (1)	1 (1)	1 (3)	0 (0)	0 (0)	0 (0)	1
II	trimethoprim-sulfamethoxazole	2 (3)	1 (1)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
III	chloramphenicol	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	<1
III	sulfisoxazole	2 (3)	1 (1)	0 (0)	1 (3)	3 (1)	0 (0)	1 (3)	0 (0)	0 (0)	1 (17)	1
III	tetracycline	11 (15)	0 (0)	0 (0)	0 (0)	10 (3)	2 (2)	1 (3)	0 (0)	0 (0)	1 (17)	4
IV												

Note: No cases were reported in the Yukon, Northwest Territories, or Nunavut.

[1] Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (See Appendix A.2)

Salmonella Heidelberg

(n=430)

The provincial/territorial incidence rates of *S.* Heidelberg varied from 0 to 9.58 (median=1.79) cases per 100,000 inhabitant-years. No cases were reported in the Yukon or the Northwest Territories. The most frequent phage types were PT 19 (37%, 159/430), PT 29 (7%, 28/430), and PT 18a (5%, 22/430). Eight percent (34/430) of isolates were cultured from blood and 4% (16/430) were cultured from urine (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results are presented in Table 3, Table 9, and Table 37 (Appendix B.1). Resistance to one or more antimicrobials was detected in 53% (228/430) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. Intermediate susceptibility to ceftriaxone was present in 11% (49/430) of the isolates, while resistance to ceftiofur was present in 13% (57/430) of the isolates. Resistance to nalidixic acid was observed in 2% (8/430) of the isolates, and one of these isolates had both resistance to nalidixic acid and intermediate susceptibility to ceftriaxone. Reduced susceptibility to ciprofloxacin was found in 2% of isolates (9/430).

AMR Patterns: The most frequent pattern was resistance to ampicillin alone (17%, 73/430). This pattern was mainly seen across Canada among PT 19 isolates (75%, 55/73). The A2C-AMP pattern was present in 9% (37/430) of the isolates, mostly among PT 29 isolates. Resistance to five or more antimicrobials was detected in 4% (17/430) of the isolates. The ACSSuT-A2C pattern was present in less than 1% (2/430) of the isolates and was recovered in Manitoba (PT 41) and Nova Scotia (PT 19). One PT 52 isolate from Québec had resistance to ACKSSuT-A2C, and one PT54 isolate in New Brunswick had resistance to ACKSSuT-A2C-GEN. One Ontario isolate (PT 29) had resistance to A2C-AMP-NAL. The frequency of A2C-AMP was 6% (2/34) among the blood isolates and 25% (4/16) among the urine isolates.

Temporal Variations: See Figure 2. Ceftiofur resistance increased significantly between 2003 and 2004, but decreased between 2004 and 2005. In 2006, ceftiofur resistance continued to decrease, and was lower in 2006 compared to 2003. The A2C-AMP pattern was less frequent in 2006 compared to 2003. Fewer blood isolates had this pattern in 2006 compared to previous years. The prevalence of resistance to gentamicin was highest in 2003 (4%, 24/599), but has increased from 1% (4/407) in 2005 to 3% (14/430) in 2006.

Among human *S.* Heidelberg, the prevalence of ceftiofur resistance continued to decrease in 2006, and is lower than in 2003. Ceftriaxone resistance was not detected in 2006; only 11% of the isolates had reduced susceptibility compared to 26% in 2004 (142/556) and 2005 (105/407).

Table 3. Individual antimicrobial drug resistance in human *Salmonella* Heidelberg isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

Antimicrobial	BC N=29 n (%)	AB N=46 n (%)	SK N=14 n (%)	MB N=21 n (%)	ON N=122 n (%)	QC N=96 n (%)	NB N=72 n (%)	NS N=16 n (%)	PEI N=6 n (%)	NL N=7 n (%)	Canada %
amoxicillin-clavulanic acid	5 (17)	4 (9)	1 (7)	6 (29)	12 (10)	8 (8)	15 (21)	2 (13)	3 (50)	1 (14)	12
ceftiofur	5 (17)	4 (9)	1 (7)	6 (29)	12 (10)	8 (8)	15 (21)	2 (13)	3 (50)	1 (14)	12
ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
ampicillin	8 (28)	20 (43)	6 (43)	17 (81)	44 (36)	36 (38)	22 (31)	6 (38)	3 (50)	5 (71)	38
cefoxitin	5 (17)	3 (7)	1 (7)	5 (24)	12 (10)	6 (6)	13 (18)	2 (13)	3 (50)	1 (14)	11
gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	6 (5)	5 (5)	3 (4)	0 (0)	0 (0)	0 (0)	3
kanamycin	0 (0)	1 (2)	0 (0)	0 (0)	1 (1)	2 (2)	1 (1)	0 (0)	0 (0)	0 (0)	1
nalidixic acid	0 (0)	1 (2)	0 (0)	1 (5)	4 (3)	1 (1)	0 (0)	0 (0)	0 (0)	1 (14)	2
streptomycin	5 (17)	9 (20)	0 (0)	3 (14)	19 (16)	11 (11)	9 (13)	1 (6)	0 (0)	0 (0)	14
trimethoprim-sulfamethoxazole	0 (0)	0 (0)	0 (0)	0 (0)	5 (4)	4 (4)	0 (0)	0 (0)	0 (0)	1 (14)	3
chloramphenicol	0 (0)	0 (0)	0 (0)	1 (5)	2 (2)	1 (1)	1 (1)	1 (6)	0 (0)	0 (0)	1
sulfisoxazole	2 (7)	1 (2)	0 (0)	1 (5)	12 (10)	11 (11)	1 (1)	2 (13)	0 (0)	0 (0)	8
tetracycline	9 (31)	12 (26)	3 (21)	3 (14)	10 (8)	12 (13)	6 (8)	2 (13)	0 (0)	1 (14)	14

Note: No cases were reported in the Yukon or the Northwest Territories. One isolate from Nunavut was resistant to ampicillin, but was not included in this table.

[1] Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (Appendix A.2).

Salmonella Newport

(n=146)

The provincial/territorial incidence rates of *S.* Newport varied from 0 to 0.68 (median=0.19) cases per 100,000 inhabitant-years. No cases were reported in the Yukon, Northwest Territories, Nunavut, or Prince Edward Island. The most frequent phage types were PT 9 (13%, 19/146), PT 3 (12%, 18/146), and PT 4 (11%, 16/146). All the blood isolates were fully susceptible. Three percent of the isolates were cultured from blood samples (5/146) and 8% of the isolates were cultured from urine samples (11/146) (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results are presented in Table 4, Table 9, and Table 38 (Appendix B.1). Resistance to one or more antimicrobials was detected in 23% (33/146) of the isolates. No isolates were resistant to ciprofloxacin, amikacin, or gentamicin. Resistance to ceftriaxone was present in 1% (2/146) of the isolates. Six percent (9/146) of the isolates had intermediate susceptibility to ceftriaxone. Resistance to ceftiofur was present in 8% (12/145) of the isolates. Resistance to nalidixic acid was present in 5% (7/146) of the isolates. Reduced susceptibility to ciprofloxacin was present in 4% (6/146) of the isolates.

AMR Patterns: The most frequent pattern was resistance to tetracycline alone (5%, 8/146). This pattern was observed in two isolates from British Columbia (PT 11 and PT 3), and six isolates from Ontario (PT 16, PT 17a, and four atypical phage type isolates). Also, one atypical phage type isolate from Ontario was resistant to nalidixic acid. Resistance to five or more antimicrobials was detected in 11% (16/146) of the isolates. The ACSSuT-A2C pattern was observed in 4% (6/146) of the isolates. Among these, one PT 17 isolate in British Columbia had additional resistance to nalidixic acid (a pattern not seen in other serovars), and one PT 14a in British Columbia had additional resistance to ceftriaxone. A PT 14b isolate from British Columbia had the ACKSSuT-NAL-SXT pattern. Two percent (3/146) of the isolates had resistance to ACKSSuT-A2C, and one PT 14a Ontario isolate from urine was additionally resistant to ceftriaxone and trimethoprim-sulfamethoxazole.

Temporal Variations: See Figure 2. A significant increase in resistance to one or more antimicrobials was observed in 2006 to (23% (33/146) compated to 2005 (11%, 16/142). Similarly, a significant increase in resistance to nalidixic acid (5%, 7/146) and reduced susceptibility to ciprofloxacin (4%, 6/146) of the isolates in 2006 was observed, whereas no isolates had resistance to nalidixic acid or reduced susceptibility to ciprofloxacin in 2005. No other significant changes were identified.

As compared to other serovars, *S.* Newport demonstrated more multidrug resistance. In 2006, 4% (6/145) of the Newport isolates had the ACSSuT-A2C pattern, and one isolate had the ACSSuT-A2C-NAL pattern with reduced susceptibility to ciprofloxacin (not seen in other serovars). One isolate had the ACSSuT-A2C-CRO resistance pattern and one had the ACKSSuT-A2C-CRO-SXT pattern.

Table 4. Individual antimicrobial drug resistance in human *Salmonella* Newport isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

Antimicrobial	BC N=20 n (%)	AB N=15 n (%)	SK N=1 n (%)	MB N=5 n (%)	ON N=85 n (%)	QC N=16 n (%)	NB N=1 n (%)	NS N=2 n (%)	PEI N=0 n (%)	NL N=1 n (%)	Canada %
amoxicillin-clavulanic acid	4 (20)	2 (13)	0 (0)	2 (40)	3 (4)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	9
ceftiofur	4 (20)	1 (7)	0 (0)	2 (40)	3 (4)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	8
ceftriaxone	1 (5)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
ampicillin	7 (35)	1 (7)	0 (0)	2 (40)	4 (5)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	12
cefoxitin	4 (20)	1 (7)	0 (0)	2 (40)	3 (4)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	8
gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
kanamycin	3 (15)	1 (7)	0 (0)	0 (0)	2 (2)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	5
nalidixic acid	3 (15)	0 (0)	0 (0)	0 (0)	4 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5
streptomycin	7 (35)	1 (7)	0 (0)	2 (40)	5 (6)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	13
trimethoprim-sulfamethoxazole	1 (5)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2
chloramphenicol	8 (40)	2 (13)	0 (0)	2 (40)	4 (5)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	12
sulfisoxazole	6 (30)	1 (7)	0 (0)	2 (40)	5 (6)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	12
tetracycline	8 (40)	1 (7)	0 (0)	2 (40)	12 (14)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	18

Note: No cases were reported in the Yukon, Northwest Territories, Nunavut, or. Prince Edward Island.

Salmonella Paratyphi A and Paratyphi B

(n=66; Paratyphi A, n= 59 and Paratyphi B, n=7)

The combined provincial/territorial incidence rate of *S.* Paratyphi A and *S.* Paratyphi B varied from 0 to 0.85 (median=0.00) cases per 100,000 inhabitant-years. No cases were reported in the Yukon, Northwest Territories, Nunavut, Saskatchewan, Manitoba, New Brunswick, Newfoundland, Nova Scotia, or Prince Edward Island. Phage typing is not applicable to Paratyphi A isolates. Among all isolates of S. Paratyphi B, the most frequent phage types were Battersea (2/7) and Dundee (2/7). Fifty-eight percent (34/59) of the Paratyphi A isolates were cultured from blood. None of the Paratyphi B isolates were cultured from blood or urine (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results are presented in Table 5, Table 9, and Table 39 (Appendix B.1). Resistance to one or more antimicrobials was detected in 93% (55/59) of the Paratyphi A isolates and 29% (2/7) of the Paratyphi B isolates. No isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, kanamycin, streptomycin, or trimethoprim-sulfamethoxazole. No intermediate susceptibility to ceftriaxone was observed. However, resistance to nalidixic acid was observed in 93% (55/59) of Paratyphi A isolates and 14% (1/7) of the Paratyphi B isolates, all of which where observed to have reduced susceptibility to ciprofloxacin. Resistance to ampicillin, chloramphenicol, sulfisoxazole, and tetracycline was not observed in the Paratyphi A isolates and was observed in one of the Paratyphi B isolates.

AMR Patterns: For Paratyphi A, the most frequent pattern was resistance to nalidixic acid alone (93%, 55/59). For Paratyphi B, the AMP-CHL-SSS-TET (1/7) pattern and resistance to nalidixic acid alone (1/7) were observed. No Paratyphi A or B isolates were resistant to five or more antimicrobials.

Temporal Variations: See Figure 3. Resistance to nalidixic acid and reduced susceptibility to ciprofloxacin significantly increased between 2003 and 2006. This increase was mainly due to the changes in the prevalence of nalidixic acid resistance and reduced susceptibility to ciprofloxacin in Paratyphi A between 2003 (70%, 19/27) and 2006 (93%, 55/59). No resistance to streptomycin or trimethoprim-sulfamethoxazole was observed in 2006, whereas 10% of isolates recovered in 2003 were resistant to each of these antimicrobials.

Resistance to nalidixic acid and reduced susceptibility to ciprofloxacin significantly increased from 2003 to 2006 and was observed in 93% (55/59) of S. Paratyphi A isolates and 14% (1/7) of S. Paratyphi B isolates in 2006. Resistance to nalidixic acid and reduced susceptibility to ciprofloxacin could indicate either delayed response or clinical failure in cases of extra-intestinal *Salmonella* infections treated with fluoroquinolones.

Table 5. Individual antimicrobial drug resistance in human *Salmonella* Paratyphi A and Paratyphi B isolates by province; *Surveillance of Human Clinical Isolates*, 2006

	Antimicrobial	BC N=18 n (%)	AB N=8 n (%)	SK N=0 n (%)	MB N=0 n (%)	ON N=33 n (%)	QC N=7 n (%)	NB N=0 n (%)	NS N=0 n (%)	PEI N=0 n (%)	NL N=0 n (%)	Canada[1] %
I	amoxicillin-clavulanic acid	0 (0)	0 (0)			0 (0)	0 (0)					0
I	ceftiofur	0 (0)	0 (0)			0 (0)	0 (0)					0
I	ceftriaxone	0 (0)	0 (0)			0 (0)	0 (0)					0
I	ciprofloxacin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	amikacin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	ampicillin	0 (0)	0 (0)			0 (0)	1 (14)					2
II	cefoxitin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	gentamicin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	kanamycin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	nalidixic acid	17 (94)	8 (100)			30 (91)	1 (14)					85
II	streptomycin	0 (0)	0 (0)			0 (0)	0 (0)					0
II	trimethoprim-sulfamethoxazole	0 (0)	0 (0)			0 (0)	0 (0)					0
III	chloramphenicol	0 (0)	0 (0)			0 (0)	1 (14)					2
III	sulfisoxazole	0 (0)	0 (0)			0 (0)	1 (14)					2
III	tetracycline	0 (0)	0 (0)			0 (0)	1 (14)					2
IV												

Note: No cases were reported in the Yukon, Northwest Territories, Nunavut, Saskatchewan, Manitoba, New Brunswick, Newfoundland, Prince Edward Island, or Nova Scotia.

[1] Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (See Appendix A.2).

Salmonella Typhi

(n=164)

The provincial/territorial incidence rate of *S.* Typhi varied from 0 to 1.01 (median=0.09) cases per 100,000 inhabitant-years. No cases were reported in the Yukon, Northwest Territories, Nunavut, New Brunswick, Prince Edward Island, or Nova Scotia. The most frequent phage types were PT E1 (38%, 63/164), PT G3 (10%, 17/164), PT D1 (8%, 13/164), and PT E14 (5%, 9/164). The phage type could not be identified for 9% (14/164) of the isolates. Forty-nine percent (80/164) of the isolates were cultured from blood and no isolates were cultured from urine (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results for *S.* Typhi are presented in Table 6, Table 9, and Table 40 (Appendix B.1). Resistance to one or more antimicrobials was detected in 82% (134/164) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or gentamicin. No intermediate susceptibility to ceftriaxone was observed. Resistance to nalidixic acid and reduced susceptibility to ciprofloxacin was observed in 80% (131/164) and 80% (132/164) of the isolates, respectively.

AMR Patterns: The most frequent pattern was resistance to nalidixic acid alone (61%, 100/164; including 53 blood isolates). The most frequent phagetypes resistant to nalidixic acid alone were PT E1 (43%, 43/100) and PT D1 (12%, 12/100). Resistance to five or more antimicrobials was detected in 16% (26/164) of the isolates. Five percent of isolates (9/164) were resistant to ACSSuT-NAL-SXT, including five isolates from British Columbia (4 PT E1 and 1 PT E9), three from Ontario [1 PT E1 and 2 UVS (I+IV)], and one untypable isolate from Québec. One PT E1 isolate from Québec was resistant to ACSSuT-AMC-SXT. In Ontario, the A2C-AMP-NAL pattern was observed in one PT E1 isolate

and the A2C-AMP-CHL-NAL-TET in one PT G3 isolate. Sixteen percent (13/80) of the blood isolates were susceptible to all antimicrobials tested, while 13% (10/80) of the blood isolates had resistance to between five and seven antimicrobials. Two blood isolates were resistant to ACSSuT-NAL-SXT, seven blood isolates to AMP-CHL-NAL-STR-SSS-SXT, and one blood isolate was resistant to A2C-AMP-CHL-NAL-TET.

Temporal Variations: See Figure 3. As was observed in 2005, resistance to nalidixic acid continues to be of concern, as its prevalence has increased from 45% (55/123) in 2003 to 80% (131/164) in 2006. This increase was not attributed to the increase or decrease of a particular phage type. Similar concerns surround the increasing prevalence of reduced susceptibility to ciprofloxacin from 50% (62/126) in 2003 to 80% (132/164) in 2006.

The prevalence of resistance to nalidixic acid among S. Typhi continues to be of concern as it increased significantly from 45% in 2003 to 80% in 2006. Significant increases were also observed in S. Typhi isolates with reduced susceptibility to ciprofloxacin from 50% in 2003 to 80% in 2006.

Table 6. Individual antimicrobial drug resistance in human *Salmonella* Typhi isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

	Antimicrobial	BC N=43 n (%)	AB N=10 n (%)	SK N=1 n (%)	MB N=1 n (%)	ON N=92 n (%)	QC N=16 n (%)	NB N=0 n (%)	NS N=0 n (%)	PEI N=0 n (%)	NL N=1 n (%)	Canada %
I	amoxicillin-clavulanic acid	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	1 (6)				0 (0)	2
	ceftiofur	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)				0 (0)	1
	ceftriaxone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	0
	ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	0
II	amikacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	0
	ampicillin	8 (19)	1 (10)	0 (0)	0 (0)	17 (18)	4 (25)				0 (0)	18
	cefoxitin	0 (0)	0 (0)	0 (0)	0 (0)	3 (3)	0 (0)				0 (0)	2
	gentamicin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	0
	kanamycin	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)				0 (0)	<1
	nalidixic acid	31 (72)	10 (100)	0 (0)	0 (0)	80 (87)	9 (56)				1 (100)	80
	streptomycin	6 (14)	1 (10)	0 (0)	0 (0)	13 (14)	3 (19)				0 (0)	14
	trimethoprim-sulfamethoxazole	6 (14)	1 (10)	0 (0)	0 (0)	14 (15)	4 (25)				0 (0)	15
III	chloramphenicol	8 (19)	1 (10)	0 (0)	0 (0)	15 (16)	3 (19)				0 (0)	16
	sulfisoxazole	6 (14)	1 (10)	0 (0)	0 (0)	14 (15)	4 (25)				0 (0)	15
	tetracycline	7 (16)	0 (0)	0 (0)	0 (0)	7 (8)	3 (19)				0 (0)	10
IV												

Note: No cases reported in the Yukon, Northwest Territories, Nunavut, New Brunswick, Prince Edward Island, or Nova Scotia.

Salmonella Typhimurium

(n=539)

The provincial/territorial incidence rates of *S.* Typhimurium varied from 0 to 7.24 (median 2.50) cases per 100,000 inhabitant-years. No cases were reported in the Yukon, Northwest Territories, or Nunavut. Among all isolates the most frequent phage types were PT 170 (15%, 82/539), PT 104 (69/539), and PT UT1 (6%, 34/539). Two percent of isolates were cultured from blood (9/539) and 2% from urine (9/539) (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results are presented in Table 7, Table 9, and Table 41 (Appendix B.1). Resistance to one or more antimicrobials was detected in 47% (252/539) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. Two percent (8/539) of the isolates had intermediate susceptibility to ceftriaxone. Resistance to ceftiofur was present in 1% (8/539) of the isolates and resistance to nalidixic acid was present in 2% of the isolates (11/539). Reduced susceptibility to ciprofloxacin was present in 5% (25/539) of the isolates.

AMR Patterns: Resistance to five or more antimicrobials was detected in 27% (144/539) of the isolates. The most frequent patterns were resistance to ACSSuT (9%, 51/539) or ACKSSuT alone (8%, 43/539), or in combination with resistance to other antimicrobials (4%, 20/539). Most isolates with the ACSSuT pattern were PT 104 or PT 104b, while most ACKSSuT patterns were PT U302 or PT 104. The AKSSuT pattern was present in less than 1% of isolates (2/539) and mainly observed in PT 208 and PT 99. This pattern was also observed with additional resistance to trimethoprim-sulfamethoxazole (<1%, 3/539) in PT 208 var., PT UT5, and PT UT1. The A2C-AMP pattern was identified in less than 1% (4/539) of the isolates and was also observed with resistance to streptomycin or SSS-TET. The ACSSuT-A2C pattern was observed in less than 1% (2/539) of the isolates alone, or with additional resistance to GEN-SXT in less than 1% (2/539) of the isolates. Among the nine blood isolates, seven were susceptible to all antimicrobials, one isolate had the ACSSuT pattern, and one isolate was resistant to streptomycin alone. Four urine isolates were susceptible to all antimicrobials, and the other urine isolates were resistant to: ACSSuT (2 isolates), STR-TET, A2C-AMP-SSS-TET, and AMP-STR-SSS-TET-SXT.

Temporal Variations: See Figure 3. Resistance to ampicillin and tetracycline decreased significantly among S. Typhimurium isolates between 2003 and 2006. This decrease could be attributed to the decrease of the proportion of multidrug resistant ACSSuT PT 104 isolates among all S. Typhimurium isolates between 2003 and 2006 (from 21%, 127/605 to 8%, 42/537). Overall, the proportion of PT104 that were resistant to ACSSuT decreased from 87% (127/146) in 2003 to 61% (42/69) in 2006. Reduced susceptibility to ciprofloxacin is of concern, as it has increased significantly between 2003 (1%, 4/605) and 2006 (5%, 25/539). This increase is not explained by the increase or decrease of any particular phage type or specimen source.

Resistance to ampicillin and tetracycline decreased significantly among *S.* Typhimurium isolates between 2003 and 2006, driven by the significant decrease in the proportion of multidrug resistant (ACSSuT) PT 104 isolates. Of concern is the continued increase of reduced susceptibility to ciprofloxacin between 2003 and 2006.

Table 7. Individual antimicrobial drug resistance in human *Salmonella* Typhimurium isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

	Antimicrobial	BC N=64 n (%)	AB N=60 n (%)	SK N=21 n (%)	MB N=34 n (%)	ON N=218 n (%)	QC N=95 n (%)	NB N=27 n (%)	NS N=8 n (%)	PEI N=10 n (%)	NL N=2 n (%)	Canada[1] %
I	amoxicillin-clavulanic acid	3 (5)	2 (3)	1 (5)	1 (3)	1 (0)	4 (4)	0 (0)	0 (0)	0 (0)	0 (0)	2
I	ceftiofur	1 (2)	2 (3)	0 (0)	0 (0)	1 (0)	4 (4)	0 (0)	0 (0)	0 (0)	0 (0)	2
I	ceftriaxon	0 (0)	0 (0)	0 (0)	0 (0)	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 (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	26 (41)	20 (33)	3 (14)	8 (24)	63 (29)	40 (42)	0 (0)	2 (25)	1 (10)	0 (0)	32
II	cefoxitin	2 (3)	2 (3)	0 (0)	0 (0)	1 (0)	4 (4)	0 (0)	0 (0)	0 (0)	0 (0)	2
II	gentamicin	1 (2)	1 (2)	0 (0)	1 (3)	2 (1)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1
II	kanamycin	14 (22)	15 (25)	4 (19)	2 (6)	31 (14)	21 (22)	1 (4)	0 (0)	1 (10)	0 (0)	17
II	nalidixic acid	5 (8)	1 (2)	0 (0)	0 (0)	3 (1)	1 (1)	1 (4)	0 (0)	0 (0)	0 (0)	2
II	streptomycin	36 (56)	26 (43)	7 (33)	4 (12)	77 (35)	40 (42)	2 (7)	2 (25)	0 (0)	1 (50)	38
II	trimethoprim-sulfamethoxazole	16 (25)	10 (17)	2 (10)	2 (6)	9 (4)	4 (4)	0 (0)	1 (13)	0 (0)	0 (0)	9
III	chloramphenicol	24 (38)	11 (18)	3 (14)	4 (12)	60 (28)	34 (36)	0 (0)	1 (13)	1 (10)	0 (0)	27
III	sulfisoxazole	32 (50)	28 (47)	6 (29)	6 (18)	75 (34)	47 (49)	4 (15)	3 (38)	1 (10)	1 (50)	39
III	tetracycline	35 (55)	23 (38)	6 (29)	9 (26)	75 (34)	48 (51)	3 (11)	2 (25)	1 (10)	1 (50)	39
IV												

Note: No cases were reported in the Yukon, Northwest Territories, or Nunavut.

[1] Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (See Appendix A.2).

Salmonella "Other Serovars"

(n=1150)

In 2006, "Other Serovars" represented 36% of all the isolates and included 167 different *Salmonella* serovars (Table 8). Among the "Other Serovars", 3% (33/1150) of the isolates were cultured from blood, and 5% (54/1150) of the isolates were cultured from urine (Table 35, Appendix B.1).

Antimicrobial Drug Resistance: Results for "Other Serovars" are presented in Table 8, Table 9, and Table 42 (Appendix B.1). In 2006, resistance to one or more antimicrobials was detected in 21% (239/1150) of the isolates. Resistance to ciprofloxacin was detected in less than 1% (2/1150) of the isolates (serovar Kentucky). Resistance to nalidixic acid was present in 5% (59/1150) of the isolates. Reduced susceptibility to ciprofloxacin was observed in 6% (64/1150) of the isolates. Resistance to ceftriaxone was identified in less than 1% (3/1150) of the isolates (serovars Anatum and Concord). Two percent (25/1150) of the isolates [Agona, Concord, Hadar, I 4,5,12:b:-, I 4,5,12:9:-, I O:4,12(:i:-), Infantis, Kiambu, Litchfield, Mbandaka, OR:m.t:-, Oranienburg, and Thompson] had intermediate susceptibility to ceftriaxone. Resistance to ceftiofur was present in 3% (31/1150) of the isolates [Agona, Anatum, Concord, Hadar, I 4,5,12:b:-, I 4,5,12:i:-, I O:4,12(:i:-), Infantis, Kiambu, Litchfield, Mbandaka, OR:m.t:-, Oranienburg, Thompson].

AMR Patterns: The most frequent patterns were resistance to tetracycline alone (3%, 32/1150) and STR-TET (2%, 24/1150). Resistance to five or more antimicrobials was detected in 5% (55/1150) of the isolates. The ACSSuT pattern (with or without resistance to other antimicrobials) was present in 2% (23/1150) of the isolates. The A2C-AMP pattern was identified with resistance to other antimicrobials in 2% (26/1150) of the isolates. The following serovars-multidrug resistant pattern combinations were identified for the first time in 2006: one I 4,5,12:i:- isolate resistant to A2C-AMP-CHL-NAL-SSS-TET, two Agona isolates resistant to A2C-AMP-SSS-TET, one Anatum isolate resistant to ACSSuT-A2C-CRO, one Concord isolate resistant to ACSSuT-TIO-GEN, one Concord isolate resistant to ACSSuT-TIO-GEN-SXT, and one Concord isolate resistant to ACSSuT-TIO-CRO-GEN-SXT. Eighty-five percent (28/33) of the blood isolates were fully susceptible, whereas 12% (4/33) of the blood isolates were resistant to two or more antimicrobials. Among the urine isolates, 89% (48/54) were fully susceptible, whereas 7% (4/54) of the urine isolates were resistant to two or more antimicrobials.

Temporal Variations: See Figure 3. There was a significant decrease in resistance to tetracycline among the "Other Serovars" between 2003 and 2006 from 20% to 15%.

Among the human *Salmonella* "Other Serovars", of concern is the presence of *S.* Concord (4 isolates), which were multidrug resistant, including resistance to ACSSuT and ceftriaxone.

Table 8. Individual antimicrobial drug resistance in "Other Serovars" of human *Salmonella* isolates by province; *Surveillance of Human Clinical Isolates*, 2006.

	Antimicrobial	BC N=149 n (%)	AB N=128 n (%)	SK N=61 n (%)	MB N=59 n (%)	ON N=508 n (%)	QC N=158 n (%)	NB N=45 n (%)	NS N=26 n (%)	PEI N=6 n (%)	NL N=10 n (%)	Canada[1] %
I	amoxicillin-clavulanic acid	4 (3)	5 (4)	3 (5)	2 (3)	12 (2)	3 (2)	0 (0)	0 (0)	0 (0)	1 (10)	3
	ceftiofur	4 (3)	6 (5)	1 (2)	3 (5)	11 (2)	3 (2)	0 (0)	2 (8)	0 (0)	1 (10)	3
	ceftriaxone	0 (0)	2 (2)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	<1
	ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	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
	ampicillin	7 (5)	8 (6)	6 (10)	9 (15)	24 (5)	15 (9)	0 (0)	5 (19)	3 (50)	2 (20)	6
	cefoxitin	4 (3)	5 (4)	1 (2)	1 (2)	11 (2)	3 (2)	0 (0)	0 (0)	0 (0)	1 (10)	2
	gentamicin	2 (1)	1 (1)	1 (2)	2 (3)	3 (1)	5 (3)	0 (0)	2 (8)	0 (0)	1 (10)	1
	kanamycin	0 (0)	3 (2)	1 (2)	0 (0)	9 (2)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1
	nalidixic acid	15 (10)	3 (2)	1 (2)	0 (0)	27 (5)	9 (6)	1 (2)	1 (4)	0 (0)	2 (20)	5
	streptomycin	19 (13)	18 (14)	6 (10)	11 (19)	37 (7)	15 (9)	1 (2)	6 (23)	2 (33)	1 (10)	10
	trimethoprim-sulfamethoxazole	9 (6)	5 (4)	0 (0)	2 (3)	23 (5)	3 (2)	3 (7)	1 (4)	0 (0)	0 (0)	4
III	chloramphenicol	4 (3)	7 (5)	7 (11)	5 (8)	7 (1)	7 (4)	3 (7)	5 (19)	0 (0)	0 (0)	3
	sulfisoxazole	16 (11)	12 (9)	10 (16)	9 (15)	38 (7)	17 (11)	5 (11)	5 (19)	3 (50)	2 (20)	10
	tetracycline	30 (20)	25 (20)	12 (20)	10 (17)	50 (10)	28 (18)	6 (13)	8 (31)	2 (33)	2 (20)	15
IV												

[1] Estimated percentage for Canada corrected for non-proportional submission scheme between provinces (See Appendix A.2).

Table 9. Number of antimicrobials in resistance pattern of human *Salmonella* isolates across provinces and serovars; *Surveillance of Human Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
British Columbia					
Enteritidis	71 (18)	49	21	1	0
Typhimurium	64 (16.2)	24	15	23	2
Typhi	43 (10.9)	12	24	7	0
Heidelberg	29 (7.4)	13	13	3	0
Newport	20 (5.1)	10	3	5	2
Paratyphi A	17 (4.3)	0	17	0	0
Hadar	13 (3.3)	0	13	0	0
Stanley	11 (2.8)	6	4	1	0
Paratyphi B var. L(+) tartrate+	10 (2.5)	9	1	0	0
Infantis	9 (2.3)	6	3	0	0
Less frequent serovars	107 (27.2)	88	13	6	0
Total	**394 (100)**	**217**	**127**	**46**	**4**
Alberta					
Enteritidis	101 (27.4)	78	23	0	0
Typhimurium	60 (16.3)	26	19	14	1
Heidelberg	46 (12.5)	14	32	0	0
Hadar	18 (4.9)	10	8	0	0
Newport	15 (4.1)	13	1	1	0
Typhi	10 (2.7)	0	9	1	0
Less frequent serovars	118 (32.1)	88	25	3	2
Total	**368 (100)**	**229**	**117**	**19**	**3**
Saskatchewan					
Enteritidis	34 (25.8)	24	10	0	0
Typhimurium	21 (15.9)	13	6	2	0
Heidelberg	14 (10.6)	5	9	0	0
I 4,5,12:i:-	7 (5.3)	4	1	2	0
Paratyphi B var. L(+) tartrate+	7 (5.3)	7	0	0	0
Thompson	7 (5.3)	4	3	0	0
Javiana	5 (3.8)	5	0	0	0
Agona	3 (2.3)	2	1	0	0
Hadar	3 (2.3)	0	3	0	0
Infantis	3 (2.3)	3	0	0	0
Less frequent serovars	28 (21.2)	24	3	1	0
Total	**132 (100)**	**91**	**36**	**5**	**0**
Manitoba					
Enteritidis	35 (22.6)	25	10	0	0
Typhimurium	34 (21.9)	22	8	4	0
Heidelberg	21 (13.5)	3	17	1	0
Anatum	5 (3.2)	4	1	0	0
Newport	5 (3.2)	3	0	2	0
Muenchen	4 (2.6)	4	0	0	0
Poona	4 (2.6)	4	0	0	0
Stanley	4 (2.6)	2	1	1	0
Thompson	4 (2.6)	4	0	0	0
Less frequent serovars	39 (25.2)	28	7	4	0
Total	**155 (100)**	**99**	**44**	**12**	**0**

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

Table 9 (Continued). Number of antimicrobials in resistance pattern of human *Salmonella* isolates across provinces and serovars; *Surveillance of Human Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Ontario					
Enteritidis	298 (22)	233	63	2	0
Typhimurium	218 (16.1)	134	22	62	0
Heidelberg	122 (9)	58	59	5	0
Typhi	92 (6.8)	10	67	15	0
Newport	85 (6.3)	70	11	2	2
Thompson	58 (4.3)	55	3	0	0
Paratyphi A	32 (2.4)	2	30	0	0
Less frequent serovars	451 (33.3)	369	69	13	0
Total	**1356 (100)**	**931**	**324**	**99**	**2**
Québec					
Heidelberg	96 (20.1)	48	47	0	1
Typhimurium	95 (19.9)	34	27	34	0
Enteritidis	89 (18.7)	73	16	0	0
Saintpaul	34 (7.1)	32	2	0	0
Newport	16 (3.4)	12	2	0	2
Typhi	16 (3.4)	5	8	3	0
Thompson	11 (2.3)	10	1	0	0
Less frequent serovars	120 (25.2)	89	17	13	1
Total	**477 (100)**	**303**	**120**	**50**	**4**
New Brunswick					
Heidelberg	72 (40)	48	18	5	1
Enteritidis	35 (19.4)	26	9	0	0
Typhimurium	27 (15)	21	6	0	0
I 4,5,12:i:-	5 (2.8)	4	1	0	0
Poona	5 (2.8)	5	0	0	0
Saintpaul	5 (2.8)	5	0	0	0
Schwarzengrund	4 (2.2)	3	1	0	0
Thompson	4 (2.2)	4	0	0	0
Less frequent serovars	23 (12.8)	18	4	1	0
Total	**180 (100)**	**134**	**39**	**6**	**1**
Nova Scotia					
Enteritidis	33 (38.8)	19	14	0	0
Heidelberg	16 (18.8)	9	6	1	0
Typhimurium	8 (9.4)	3	4	1	0
Paratyphi B var. L(+) tartrate+	3 (3.5)	0	0	3	0
Bareilly	2 (2.4)	2	0	0	0
Concord	2 (2.4)	0	0	2	0
Kiambu	2 (2.4)	0	2	0	0
Newport	2 (2.4)	2	0	0	0
Saintpaul	2 (2.4)	2	0	0	0
Stanley	2 (2.4)	2	0	0	0
Less frequent serovars	13 (15.3)	11	2	0	0
Total	**85 (100)**	**50**	**28**	**7**	**0**

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

Table 9 (Continued). Number of antimicrobials in resistance pattern of human *Salmonella* isolates across provinces and serovars; *Surveillance of Human Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Prince Edward Island					
Typhimurium	10 (33.3)	9	0	1	0
Enteritidis	16 (18.8)	6	2	0	0
Heidelberg	8 (9.4)	3	3	0	0
I 4,12:i:-	3 (3.5)	1	1	0	0
I 4,5,12:i:-	2 (2.4)	0	1	0	0
Infantis	1 (3.3)	0	1	0	0
Manhattan	1 (3.3)	1	0	0	0
Paratyphi B var. L(+) tartrate+	1 (3.3)	1	0	0	0
Total	**30 (100)**	**21**	**8**	**1**	**0**
Newfoundland and Labrador					
Heidelberg	7 (25.9)	1	6	0	0
Enteritidis	6 (22.2)	5	1	0	0
Agona	5 (18.5)	4	0	1	0
Typhimurium	2 (7.4)	1	1	0	0
Aberdeen	1 (3.7)	0	1	0	0
Bredeney	1 (3.7)	1	0	0	0
Hadar	1 (3.7)	0	0	1	0
Newport	1 (3.7)	1	0	0	0
Saintpaul	1 (3.7)	0	1	0	0
Sandiego	1 (3.7)	1	0	0	0
Typhi	1 (3.7)	0	1	0	0
Total	**27 (100)**	**14**	**11**	**2**	**0**
Nunavut					
Heidelberg	1 (100)	0	1	0	0
Total	**1 (100)**	**0**	**1**	**0**	**0**
Canada Total	**3205 (100)**	**2089**	**855**	**247**	**14**

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

Figure 2. Temporal variation of the resistance to selected antimicrobials among human *S.* Enteritidis, *S.* Heidelberg, and *S.* Newport isolates; *Surveillance of Human Clinical Isolates*, 2003-2006.

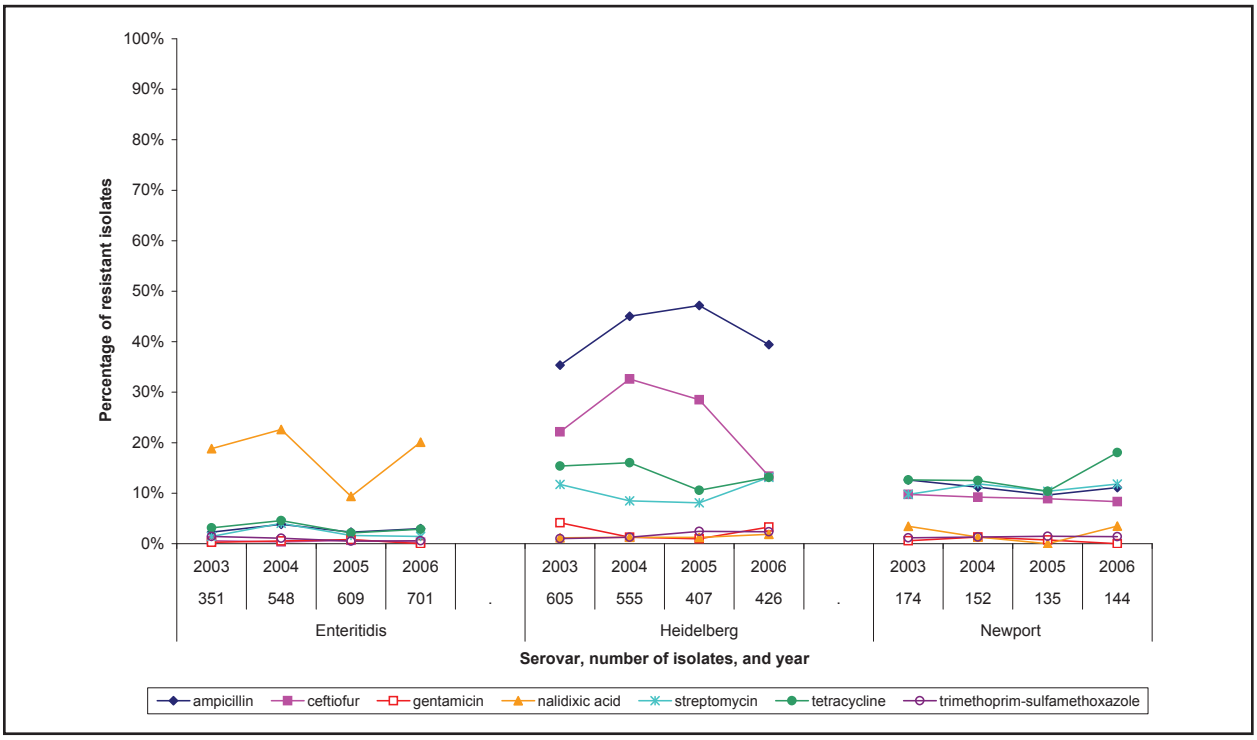
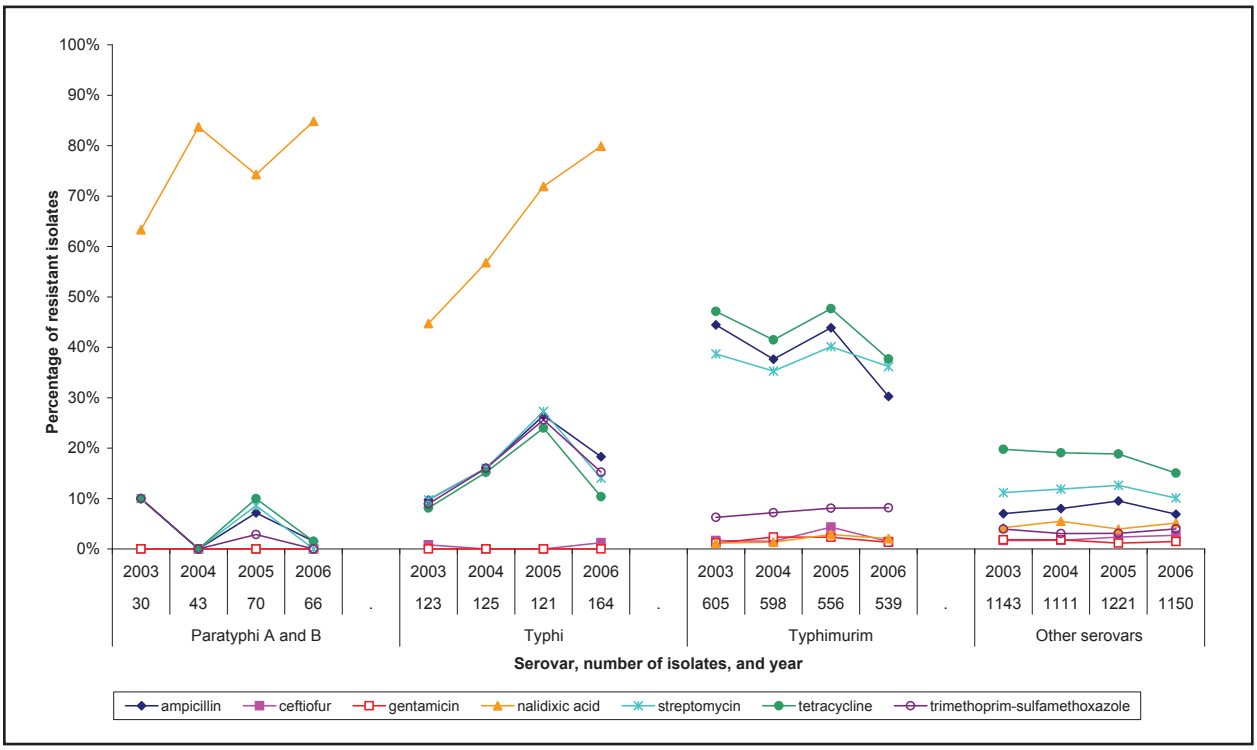


Figure 3. Temporal variation of the resistance to selected antimicrobials among human *S.* Paratyphi A and B, *S.* Typhi, *S.* Typhimurium, and "Other Serovars" isolates; *Surveillance of Human Clinical Isolates*, 2003-2006.



Box 1. Comparison of individual antimicrobial drug resistance between human *Salmonella* isolates received during the first 15 days of the month and isolates received from the remainder of the month in Alberta.

In 2005, the provincial public health laboratory in Alberta carried out antimicrobial susceptibility testing of *Salmonella* isolates that were received after the first 15 days of the month but were not sent to the National Microbiology Laboratory as per CIPARS protocol. Susceptibility results obtained through CIPARS were compared to those from the Alberta provincial lab to determine if data from isolates recovered during the first 15 days of the month were representative of the entire month (Table A.).

Overall, there were no statistically significant differences in resistance rates between isolates tested by CIPARS collected during the first half of the month compared to isolates tested by the Alberta provincial laboratory collected during the second half. This comparison confirms that conducting susceptibility testing only on isolates received during the first 15 days of the month is representative of the entire month. CIPARS aims to develop and validate the most cost-effective and efficient data collection methods while still maintaining data representativity.

Table A. Comparison of individual antimicrobial drug resistance for human *Salmonella* isolates tested by CIPARS for the first half of the month and those tested by the Alberta public health laboratory for the second half of the month 2005.

	Antimicrobial	Percentage of resistant isolates (%)							
		Enteritidis		Heidelberg		Hadar		Typhimurium	
		CIPARS[1] n=56	Prov. Lab.[2] n=78	CIPARS n=46	Prov. Lab. n=48	CIPARS n=30	Prov. Lab. n=19	CIPARS n=62	Prov. Lab. n=59
I	amoxicillin-clavulanic acid	0	0	13	4	0	0	5	0
	ceftriaxone	0	0	0	0	0	0	2	2
	ciprofloxacin	0	0	0	0	0	0	2	0
II	amikacin	0	0	0	0	0	0	0	0
	ampicillin	4	1	33	25	47	47	39	31
	cefoxitin	0	0	13	4	0	0	3	0
	gentamicin	0	0	0	2	0	0	2	2
	kanamycin	0	1	2	0	3	0	23	25
	nalidixic acid	18	12	4	0	0	0	5	0
	trimethoprim-sulfamethoxazole	0	0	4	0	0	0	3	3
III	chloramphenicol	0	0	4	0	0	0	23	15
	sulfisoxazole	2	0	4	2	3	0	42	46
	tetracycline	0	3	20	10	90	84	35	32
IV									

[1] Testing conducted by CIPARS on isolates submitted during the first 15 days of the month.

[2] Testing conducted by the Alberta Provincial Public Health Laboratory on isolates collected during the second half of the month.

Contact: Dr Marie Louie, Alberta Provincial Laboratory of Public Health.

Antimicrobial Resistance in the Agri-Food Sector

Part I – Abattoir Surveillance

Beef cattle – Generic *E. coli*

(N =150)

Recovery: Generic E. coli isolates were recovered from 100% (150/150) of the beef cattle caecal samples (Table 65, Appendix B.3).

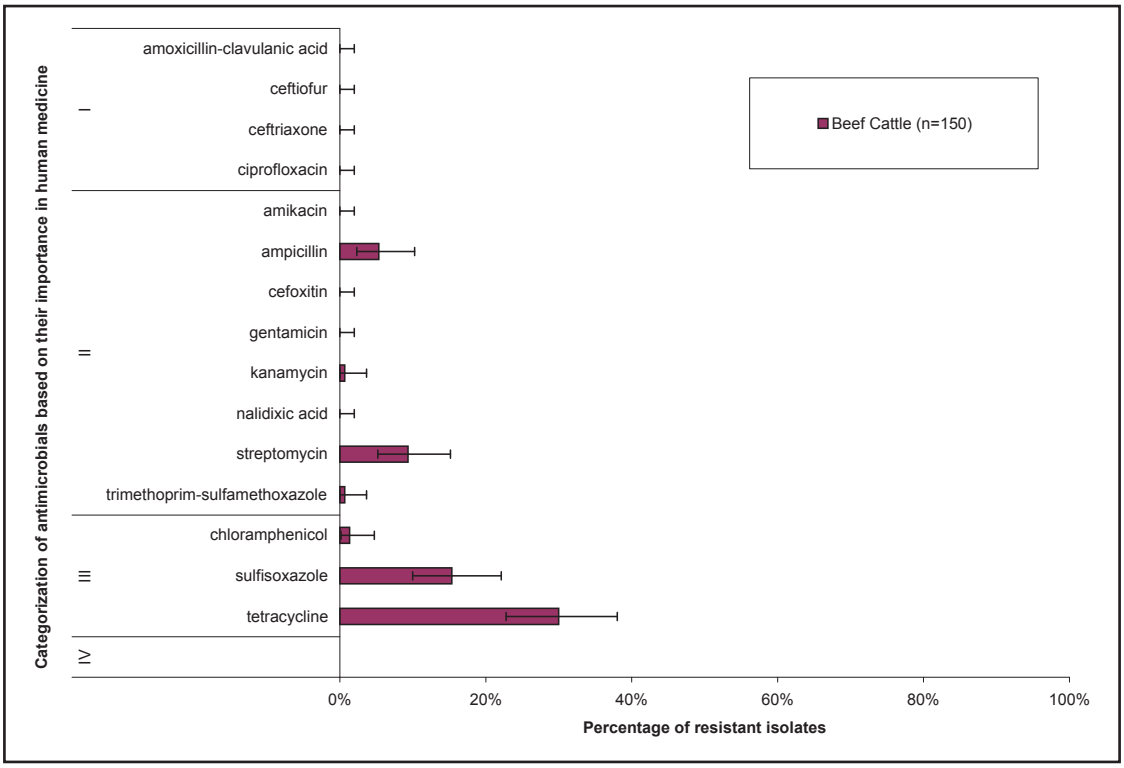
Antimicrobial Drug Resistance: See Figure 4 and Table 43 (Appendix B.2). Resistance to one or more antimicrobials was detected in 34% (51/150) of the isolates. No isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, or nalidixic acid. No intermediate susceptibility to ceftriaxone and no reduced susceptibility to ciprofloxacin was observed.

AMR Patterns: The most frequent patterns were resistance to tetracycline alone (11%, 17/150) and SSS-TET (7%, 11/150). Resistance to five or more antimicrobials was detected in one isolate.

Temporal Variations: See Figure 10. Between 2003 and 2006, no significant changes were identified.

In 2006, among abattoir beef cattle *E. coli* isolates resistance to one or more antimicrobials was detected in 34% (51/150) of the isolates. One isolate (1/150) was resistant to five or more antimicrobials. No isolates were resistant to Category I antimicrobials.

Figure 4. Individual antimicrobial drug resistance in beef cattle *E. coli* isolates, including 95% confidence intervals; *Abattoir Surveillance*, 2006.



Beef Cattle – *Campylobacter*

(N=105; *C. jejuni* - n=77; *C. coli* - n=21; *Campylobacter* spp. – n=7)

Data from October to December 2005 (23 isolates[10]) were pooled with the 2006 data (82 isolates) since there were no significant difference in prevalences of resistance between the two periods. Isolates were recovered using nine different methods tested in parallel on each sample to identify the most sensitive method. Only one isolate per sample was kept for AMR testing.

[10] Antimicrobial susceptibility testing performed on the 2005 isolates did not include telithromycine and florfenicol (E-Test® diffusion methodology, Appendix A - 2005 CIPARS Annual Report).

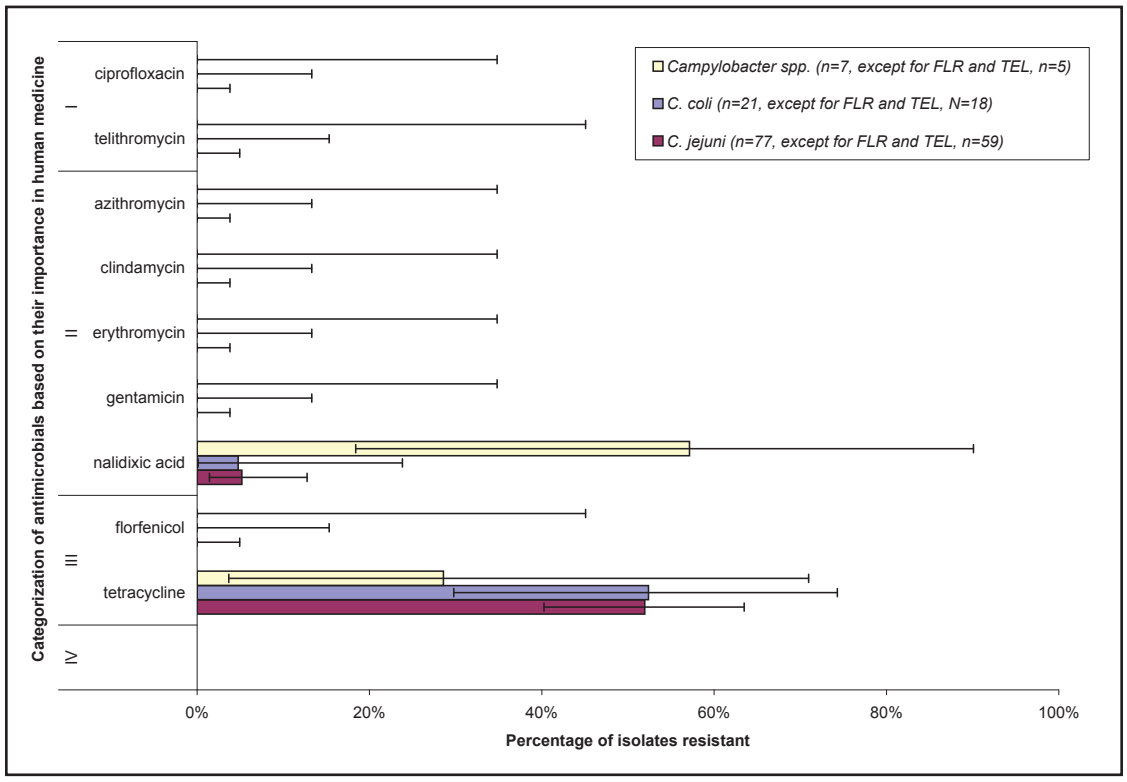
Recovery: *Campylobacter* isolates were recovered from 44%[11] (54/122) of the beef cattle caecal abattoir samples (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 5, Table 10, and Table 44 (Appendix B.2). Resistance to one or more antimicrobials was detected in 57% (60/105) of the isolates. No isolates were resistant to ciprofloxacin, telithromycin, azithromycin, clindamycin, erythromycin, gentamicin, or were non-susceptible to florfenicol. Overall, resistance to nalidixic acid was found in 9% (9/105) of the isolates. Four out of seven (4/7) *Campylobacter* spp. isolates were resistant to nalidixic acid, but these may include some species intrinsically resistant to nalidixic acid.

AMR Patterns: The most frequent patterns were resistance to tetracycline alone (49%, 51/105) and nalidixic acid alone (7%, 7/105). No isolates were resistant to three or more antimicrobials.

In 2005 and 2006, resistance to one or more antimicrobials was detected in 57% (60/105) of beef cattle *Campylobacter* isolates. Overall, nalidixic acid resistance was found in 9% (9/105) of the isolates. No isolates were resistant to Category I antimicrobials.

Figure 5. Individual antimicrobial drug resistance in beef cattle *Campylobacter* isolates across species, including 95% confidence intervals; *Abattoir Surveillance*, 2006.



Note: *Campylobacter* spp. may include some species that are intrinsically resistant to nalidixic acid.

[11] CIPARS 2006 recovery method provided a recovery rate of 44%. In order to identify the most sensitive recovery method for *Campylobacter* from caecal samples, CIPARS tested eight additional recovery methods in parallel. When results from the nine methods were pooled together, the sensitivity increased and the proportion of samples positive to *Campylobacter* reached 52% (105/200). In order to maximixe the number of isolates tested and increase the precision of our antimicrobial resistance estimates, we included isolates recovered from other methods when the initial method failed to recover *Campylobacter* (but only one isolate per sample). Only the most sensitive recovery method will be used in 2007.

Table 10. Number of antimicrobials in resistance pattern of beef cattle *Campylobacter* isolates across serovars; *Abattoir Surveillance,* 2006.

Species	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-2	3-4	5-9
		Number of isolates			
C. jejuni	77 (73.3)	34	43	0	0
C. coli	21 (20)	9	12	0	0
Campylobacter spp.	7 (6.7)	2	5	0	0
Total	**105 (100)**	**45**	**60**	**0**	**0**

Swine – Generic *E. coli*

(N=115)

Recovery: Generic *E. coli* isolates were recovered from 98% (115/117) of the swine caecal samples (Table 65, Appendix B.3).

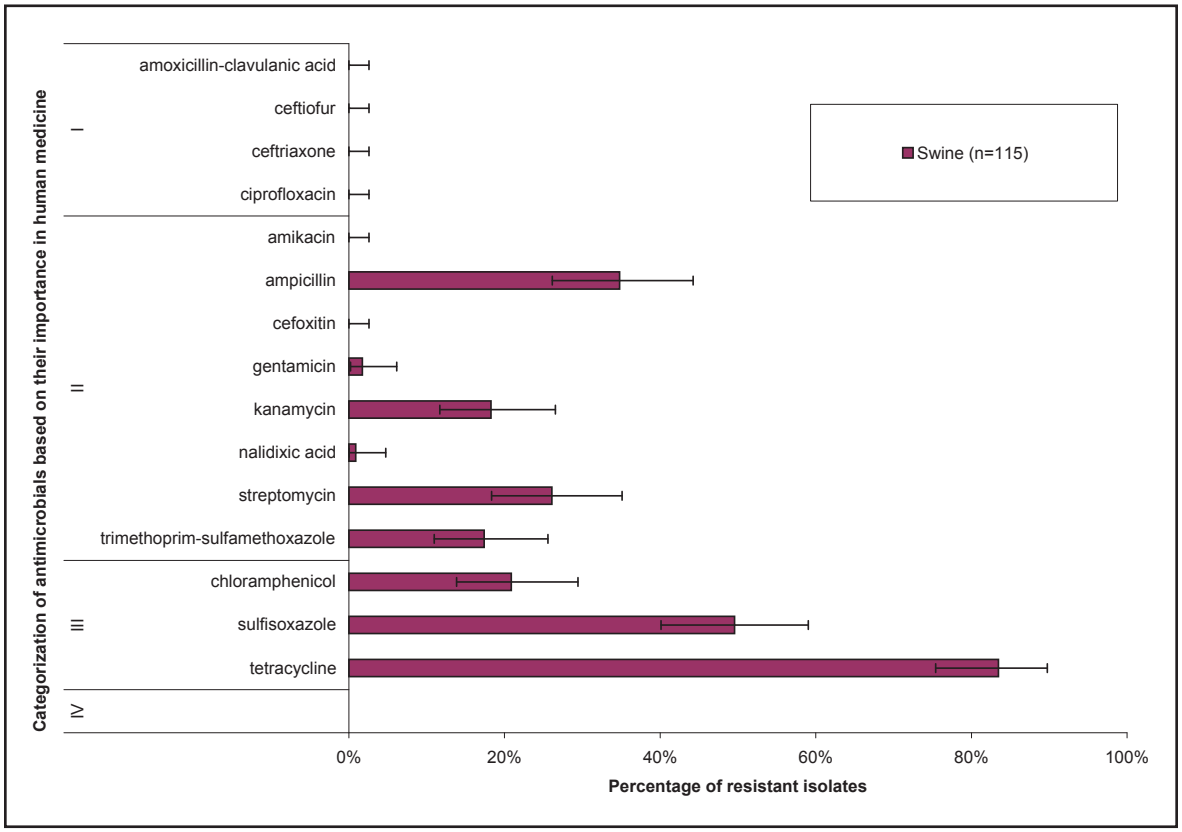
Antimicrobial Drug Resistance: See Figure 6 and Table 45 (Appendix B.2). Resistance to one or more antimicrobials was detected in 89% (102/115) of the isolates. No isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, or cefoxitin. No intermediate susceptibility to ceftriaxone was observed. One isolate was resistant to nalidixic acid and had reduced susceptibility to ciprofloxacin.

AMR Patterns: The most frequent pattern was resistance to tetracycline alone (22%, 25/115). Resistance to five or more antimicrobials was detected in 13% (15/115) of the isolates. Three isolates (3%, 3/115) had the AKSSuT pattern and three isolates (3%, 3/115) had the ACKSSuT pattern. One isolate had the ACSSuT pattern.

Temporal Variations: See Figure 10. Between 2003 and 2006, there was a significant decrease in streptomycin resistance, and this decrease occurred mainly between 2005 and 2006.

In 2006, among abattoir swine *E. coli* isolates resistance to five or more antimicrobials was detected in 13% (15/115) of the isolates. One isolate (1%, 1/115) was resistant to nalidixic acid and had reduced susceptibility to ciprofloxacin. Between 2003 and 2006, there was a significant decrease in streptomycin resistance, and this decrease occurred mainly between 2005 and 2006.

Figure 6. Individual antimicrobial drug resistance in swine *E. coli* isolates, including 95% confidence intervals; *Abattoir Surveillance*, 2006.



Swine – *Salmonella*

(N= 145)

Recovery: *Salmonella* isolates were recovered from 40% (145/359) of the swine caecal samples (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 7, Table 11, and Table 46 (Appendix B.2). Resistance to one or more antimicrobials was detected in 57% (82/145) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or nalidixic acid. Resistance to amoxicillin-clavulanic acid and ceftiofur were each found in one isolate. Intermediate susceptibility to ceftriaxone was observed in one isolate. No reduced susceptibility to ciprofloxacin was observed.

AMR Patterns: The most frequent patterns were resistance to tetracycline alone (16%, 23/145), STR-SSS-TET (8%, 11/145), and ACSSuT (6%, 9/145). Five percent (7/145) of the isolates had the ACKSSuT pattern, 1% (2/145) of the isolates had the AKSSuT pattern, and one isolate had the A2C-AMP pattern. Resistance to five or more antimicrobials was detected in 16% (23/145) of the isolates.

Serovars: See Table 11. The most frequent serovars were Derby, Typhimurium var. 5-, and Typhimurium. These three serovars accounted for 53% (77/145) of the isolates. Seventy-nine percent (30/38) of the Derby isolates, 76% (16/21) of the Typhimurium var. 5- isolates, and 78% (14/18) of the Typhimurium isolates were resistant to at least one antimicrobial. Among the "Less Common Serovars", Krefeld was resistant to five to eight antimicrobials. The ACSSuT and ACKSSuT resistance patterns were mainly composed of Typhimurium var. 5- (5/9, and 3/7 respectively) and Typhimurium (3/9, and 3/7 respectively). The AKSSuT pattern was found in one Typhimurium and one California isolate.

Temporal Variations: See Figure 11. Between 2003 and 2006 trimethoprim-sulfamethoxazole resistance significantly increased.

In 2006, among abattoir swine *Salmonella* isolates the most frequent serovars were Derby, Typhimurium var. 5, and Typhimurium. The ACSSuT and ACKSSuT resistance patterns were mainly composed of *S.* Typhimurium var. 5- (5/9, and 3/7 respectively) and *S.* Typhimurium (3/9, and 3/7 respectively). Between 2003 and 2006, trimethoprim-sulfamethoxazole resistance significantly increased.

Figure 7. Individual antimicrobial drug resistance in swine *Salmonella* isolates, including 95% confidence intervals; *Abattoir Surveillance*, 2006.

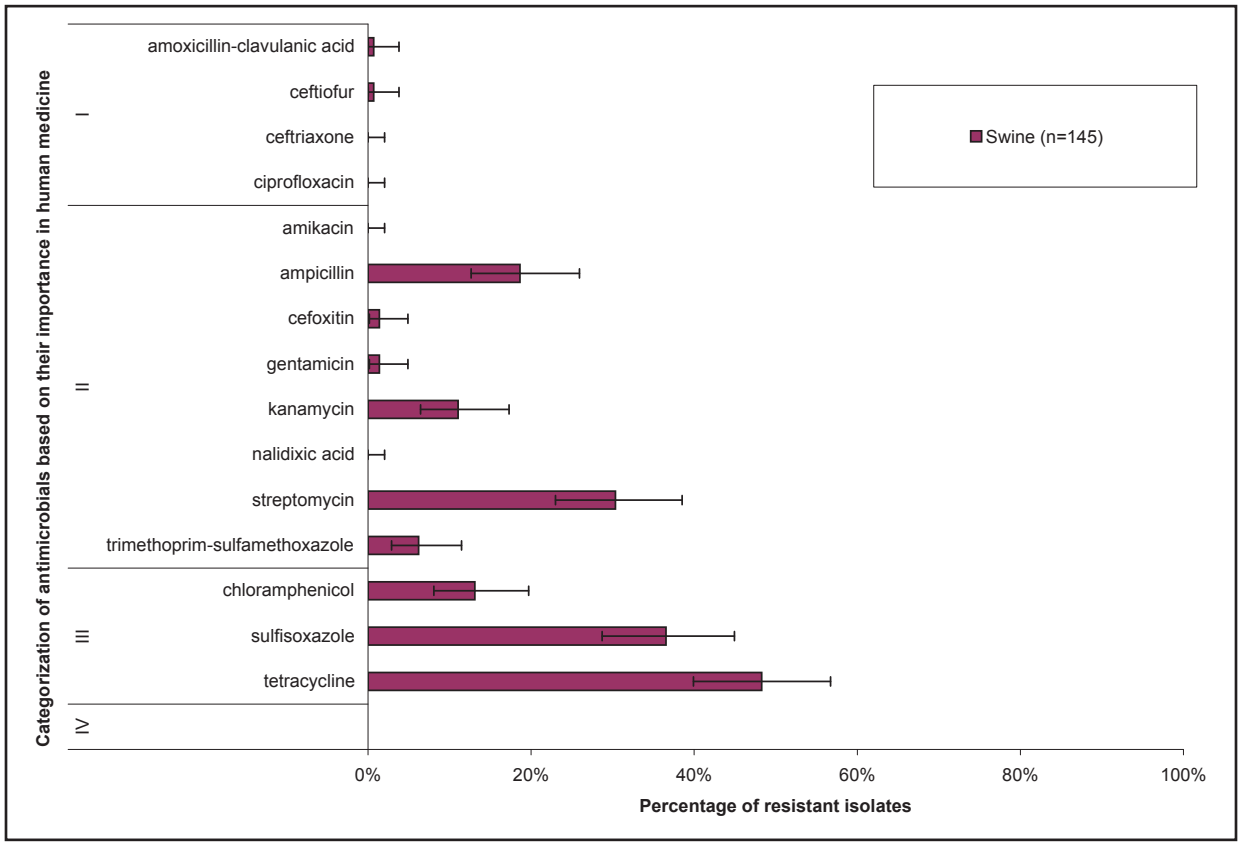


Table 11. Number of antimicrobials in resistance pattern of swine *Salmonella* isolates across serovars; *Abattoir Surveillance*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Derby	38 (26.2)	8	28	2	0
Typhimurium var. 5-	21 (14.5)	5	7	9	0
Typhimurium	18 (12.4)	4	7	7	0
Infantis	7 (4.8)	6	1	0	0
Agona	6 (4.1)	4	2	0	0
Heidelberg	6 (4.1)	1	5	0	0
Livingstone	6 (4.1)	6	0	0	0
Schwarzengrund	6 (4.1)	5	1	0	0
Brandenburg	5 (3.4)	4	1	0	0
Berta	3 (2.1)	2	1	0	0
California	3 (2.1)	0	1	2	0
Give	3 (2.1)	3	0	0	0
Mbandaka	3 (2.1)	1	0	2	0
Less frequent serovars	20 (13.8)	14	5	1	0
Total	**145 (100)**	**63**	**59**	**23**	**0**

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

Chickens – Generic *E. coli*

(N=166)

Recovery: Generic *E. coli* isolates were recovered from 100% (166/166) of caecal samples from chickens (Table 65, Appendix B.3).

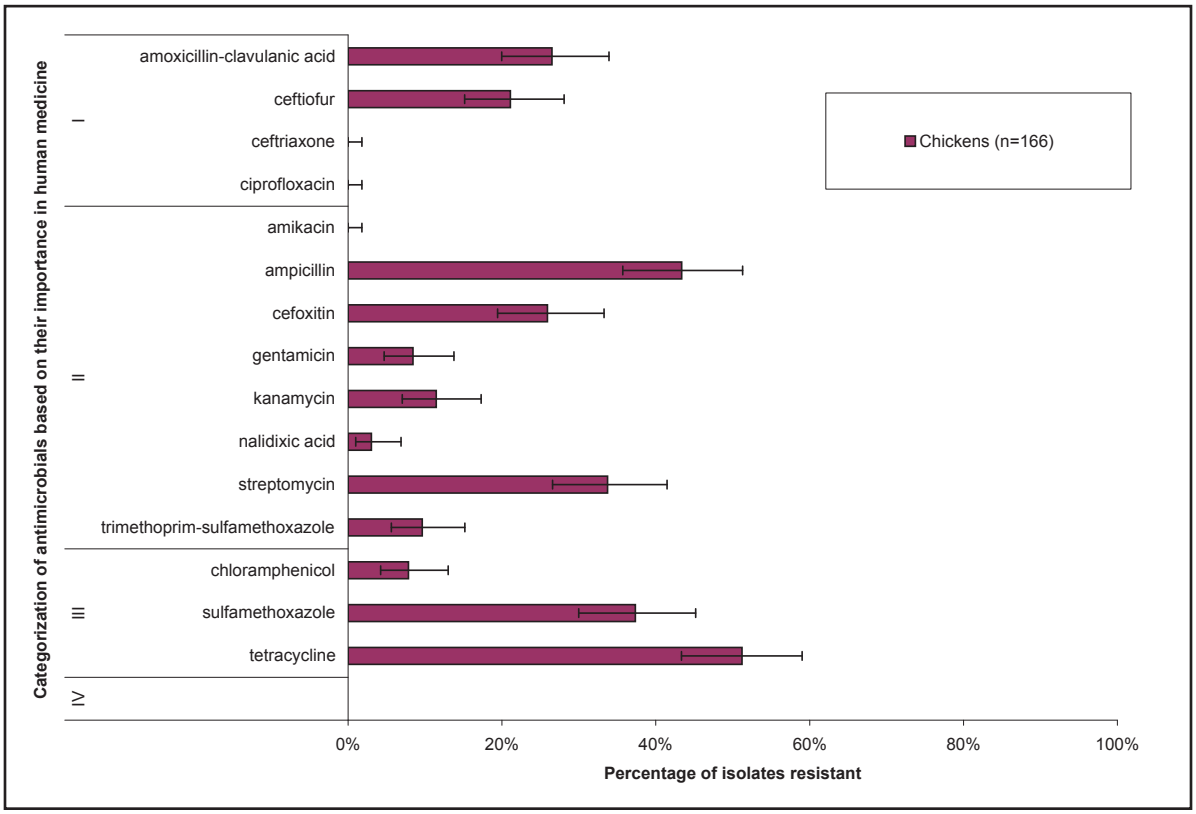
Antimicrobial Drug Resistance: See Figure 8 and Table 47 (Appendix B.2). Resistance to one or more antimicrobials was detected in 71% (118/166) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. Resistance to ceftiofur and amoxicillin-clavulanic acid was found in 21% (35/166) and 27% (44/166) of the isolates, respectively. Resistance to nalidixic acid and reduced susceptibility to ciprofloxacin was observed in 3% (5/166) of the isolates. Intermediate susceptibility to ceftriaxone was observed in 10% (17/166) of isolates. One isolate (1%, 1/166) had resistance to nalidixic acid, reduced susceptibility to ciprofloxacin and intermediate susceptibility to ceftriaxone.

AMR Patterns: The most frequent pattern was resistance to tetracycline alone (6%, 10/166). Resistance to five or more antimicrobials was detected in 23% (39/166) of the isolates. The A2C-AMP, A2C-ACSSuT, and A2C-AKSSuT patterns were observed in 14% (24/166), 5% (9/166), and 1% (2/166) of the isolates, respectively. Resistance to the AKSSuT (2%, 3/166), ACKSSuT (1%, 1/166), and ACSSuT (1%, 1/166) patterns were also observed.

Temporal Variations: See Figure 10. Between 2003 and 2006, streptomycin and tetracycline resistance significantly decreased.

In 2006 for *E. coli* isolates collected from chickens at the abattoir, resistance to nalidixic acid and reduced susceptibility to ciprofloxacin was observed in 3% (5/166) of the isolates as well as intermediate susceptibility to ceftriaxone in 10% (17/166) of the isolates. Resistance to A2C-AMP was observed in 14% (24/166) of the isolates. Between 2003 and 2006, streptomycin and tetracycline resistance significantly decreased.

Figure 8. Individual antimicrobial drug resistance in chicken *E. coli* isolates, including 95% confidence intervals; *Abattoir Surveillance*, 2006.



Chickens – *Salmonella*

(N=187)

Recovery: *Salmonella* isolates were recovered from 23% (187/824) of the caecal samples from chickens (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 9, Table 12, and Table 48 (Appendix B.2). Resistance to one or more antimicrobials was detected in 53% (99/187) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, kanamycin, or nalidixic acid and none had reduced susceptibility to ciprofloxacin. Resistance to amoxicillin-clavulanic acid, ceftiofur, or cefoxitin was each found in 10% (18/187) of the isolates. Intermediate susceptibility to ceftriaxone was observed in 7% (14/187) of the isolates.

AMR Patterns: The most frequent pattern was resistance to STR-TET (27%, 51/187). Ten percent (18/187) of the isolates had the A2C-AMP pattern. Resistance to five or more antimicrobials was detected in 2% (4/187) of the isolates.

Serovars: See Table 12. The most frequent *Salmonella* serovars were Kentucky, Heidelberg, and Enteritidis. These three serovars accounted for 71% (132/187) of the isolates. Sixty-eight percent (54/80) of the Kentucky isolates and 50% (19/38) of the Heidelberg isolates were resistant to at least one antimicrobial. All the Enteritidis isolates were fully susceptible. The predominant serovars among isolates with the A2C-AMP pattern were Heidelberg (39%, 7/18) and Kentucky (22%, 4/18). Other serovars with the A2C-AMP pattern were I 4:i:-, Thompson, Agona, Infantis, or Typhimurium. The pattern involving resistance to the greatest number of antimicrobials was A2C-AMP-STR-TET and was detected in three Kentucky isolates.

Temporal Variations: See Figure 11. Streptomycin and tetracycline resistance have significantly increased whereas ampicillin resistance has significantly decreased since 2003. Ceftiofur resistance has significantly decreased since 2004[12].

For *Salmonella* isolates collected from chickens at abattoir, between 2003 and 2006, streptomycin and tetracycline resistance have significantly increased whereas ampicillin resistance has significantly decreased. Ceftiofur resistance has significantly decreased since 2004.

Figure 9. Individual antimicrobial drug resistance in chicken *Salmonella* isolates, including 95% confidence intervals; *Abattoir Surveillance*, 2006.

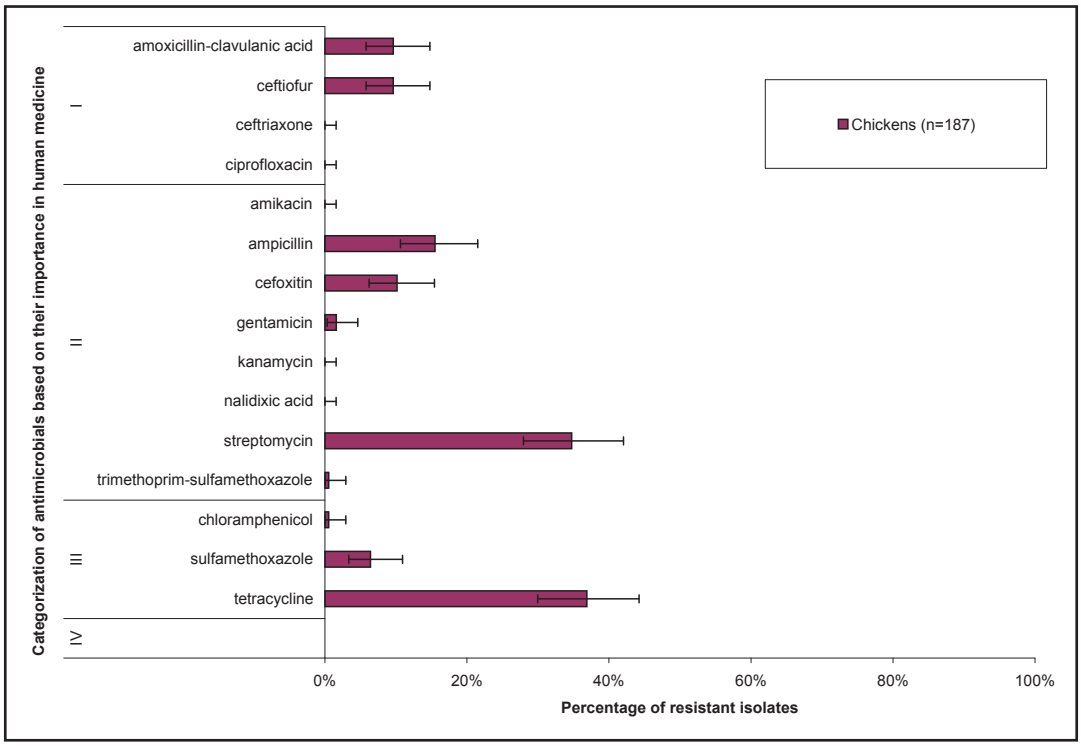


Table 12. Number of antimicrobials in resistance pattern of chicken *Salmonella* isolates across serovars; *Abattoir Surveillance*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Kentucky	80 (42.8)	26	51	3	0
Heidelberg	38 (20.3)	19	18	1	0
Enteritidis	14 (7.5)	14	0	0	0
Hadar	7 (3.7)	0	7	0	0
Typhimurium	7 (3.7)	6	1	0	0
I 4:i:-	6 (3.2)	4	2	0	0
Agona	5 (2.7)	2	3	0	0
Kiambu	5 (2.7)	4	1	0	0
Schwarzengrund	5 (2.7)	0	5	0	0
Senftenberg	4 (2.1)	4	0	0	0
Less frequent serovars	16 (8.6)	9	7	0	0
Total	**187 (100)**	**88**	**95**	**4**	**0**

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

[12] 2004 was selected as the year of reference/comparison for amoxicillin-clavulanic acid, ceftiofur, cefoxitin, and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Figure 10. Temporal variation of the resistance to selected antimicrobials of beef cattle, swine, and chicken *E. coli* isolates; *Abattoir Surveillance*, 2003-2006.

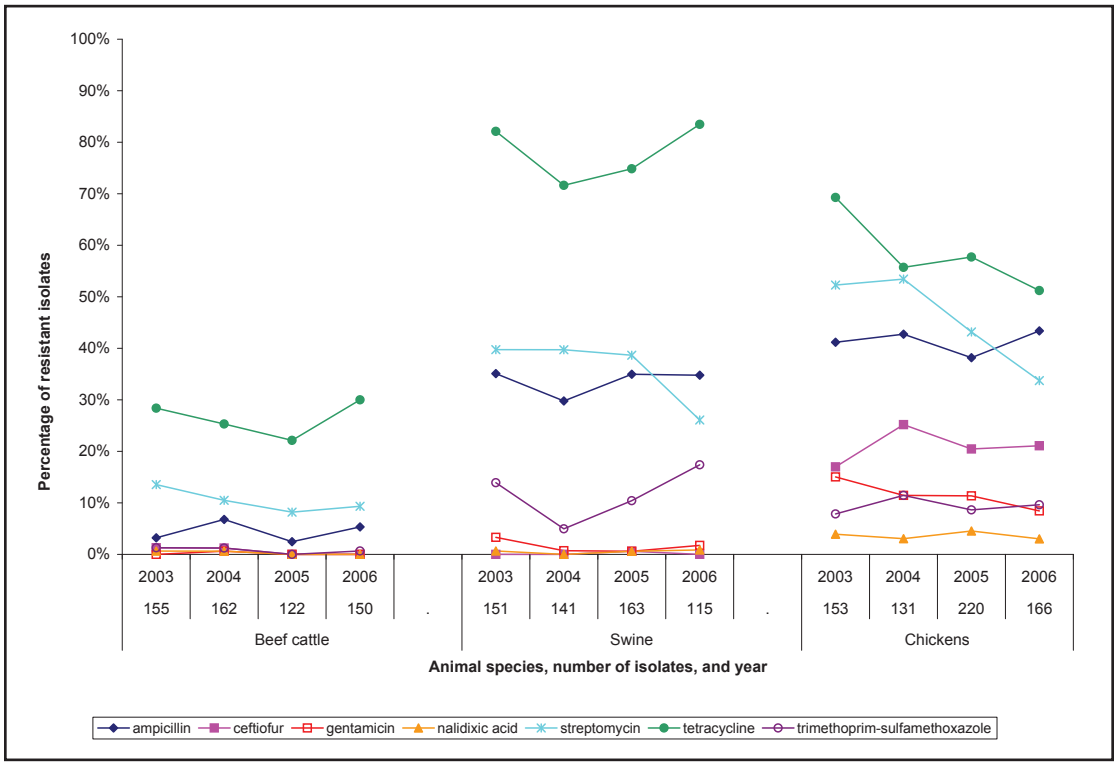
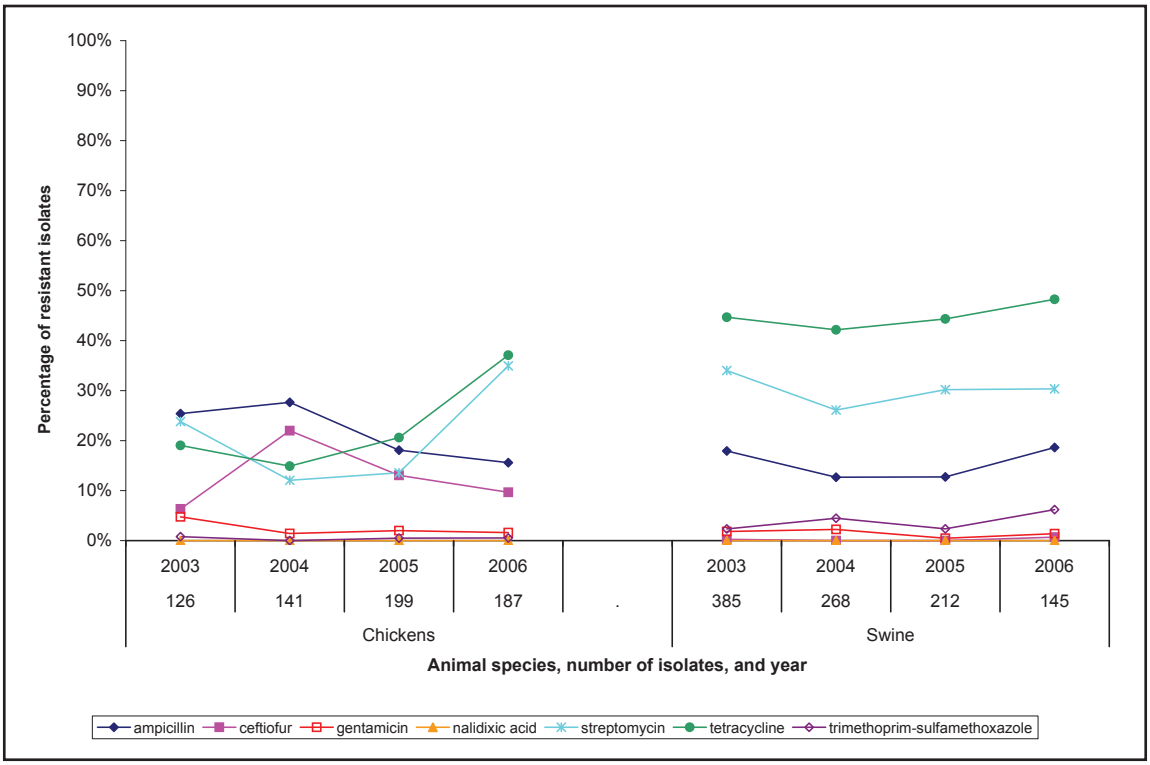


Figure 11. Temporal variation of the resistance to selected antimicrobials of chicken and swine *Salmonella* isolates; *Abattoir Surveillance*, 2003-2006.



Part II – Retail Meat Surveillance

Preliminary findings of retail pilot studies conducted in British Columbia can be found at the end of the *Retail Meat Surveillance* section.

Beef – Generic *E. coli*

(N=421; Saskatchewan n=123; Ontario n=189; Québec n=109)

Recovery: Overall, generic *E. coli* isolates were recovered from 71% (421/596) of the retail beef samples. Provincial recovery rates were: 77% (123/159) in Saskatchewan, 81% (189/232) in Ontario, and 53% (109/205) in Québec (Table 65, Appendix B.3). The annual recovery rate has been systematically lower in Québec than the other provinces since retail surveillance began. This difference cannot be explained by differences in laboratory methods, sampling protocols, or transport conditions.

Antimicrobial Drug Resistance: See Figure 12 and Table 49 (Appendix B.2). Resistance to one or more antimicrobials was detected in 10% (12/123) of the isolates from Saskatchewan, 17% (32/189) of the isolates from Ontario, and 23% (25/109) of the isolates from Québec. Across the three provinces, no isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or gentamicin. Resistance to ceftiofur (1%, 1/189), amoxicillin-clavulanic acid (1%, 2/189), and nalidixic acid (1%, 1/189; with reduced susceptibility to ciprofloxacin) were detected in isolates from Ontario. There was no significant difference between the provinces in terms of prevalence of resistance for any of the antimicrobials tested.

AMR Patterns: Across the three provinces, the most frequent patterns were resistance to tetracycline alone (7%, 29/421) and SSS-TET (4%, 15/421). Less than 1% of the isolates had the ACSSuT (2/421) or the A2C-ACSSuT (1/421) patterns; these isolates were from Ontario. Resistance to five or more antimicrobials was detected in 1% (6/421) of the isolates.

Temporal Variations: See Figure 13. Between 2003 and 2006, streptomycin resistance significantly decreased in Ontario. There were no significant changes in Saskatchewan (since 2005) or Québec (since 2003).

In 2006, among retail beef *E. coli* isolates resistance to amoxicillin-clavulanic acid (1%, 2/189), ceftiofur (1%, 1/189), and nalidixic acid (1%, 1/189) was detected among Ontario isolates. Between 2003 and 2006, streptomycin resistance significantly decreased in Ontario.

Figure 12. Individual antimicrobial drug resistance in beef *E. coli* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

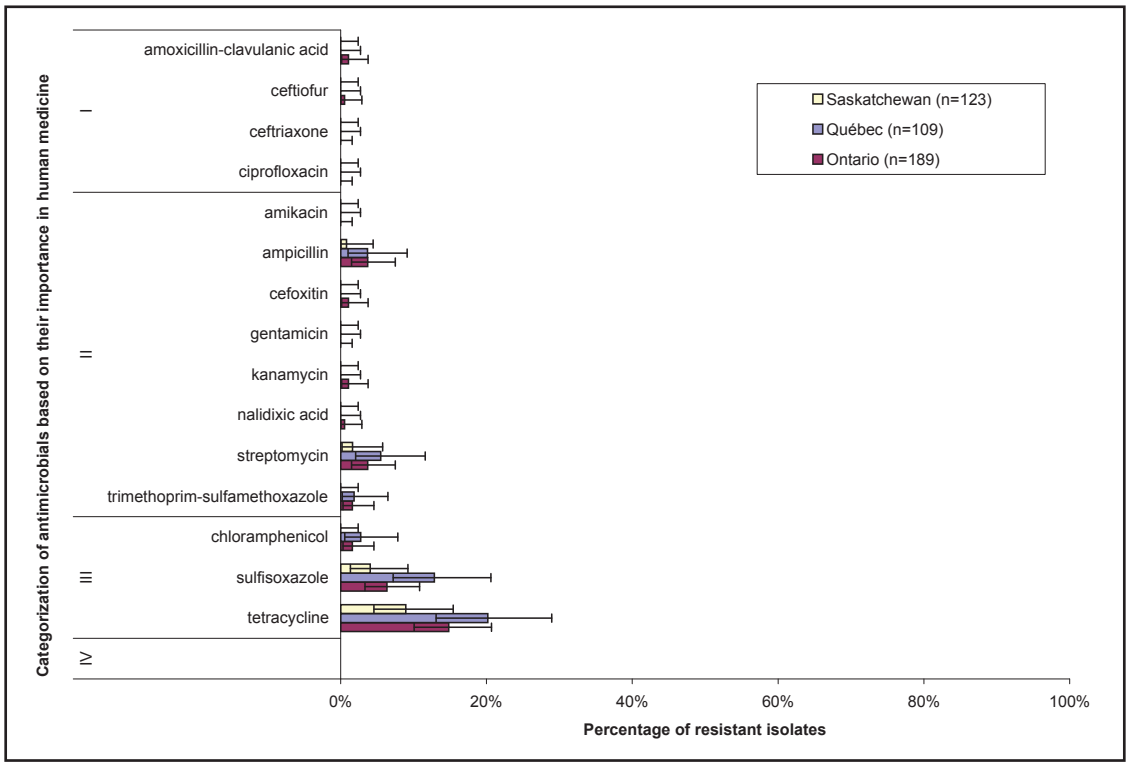
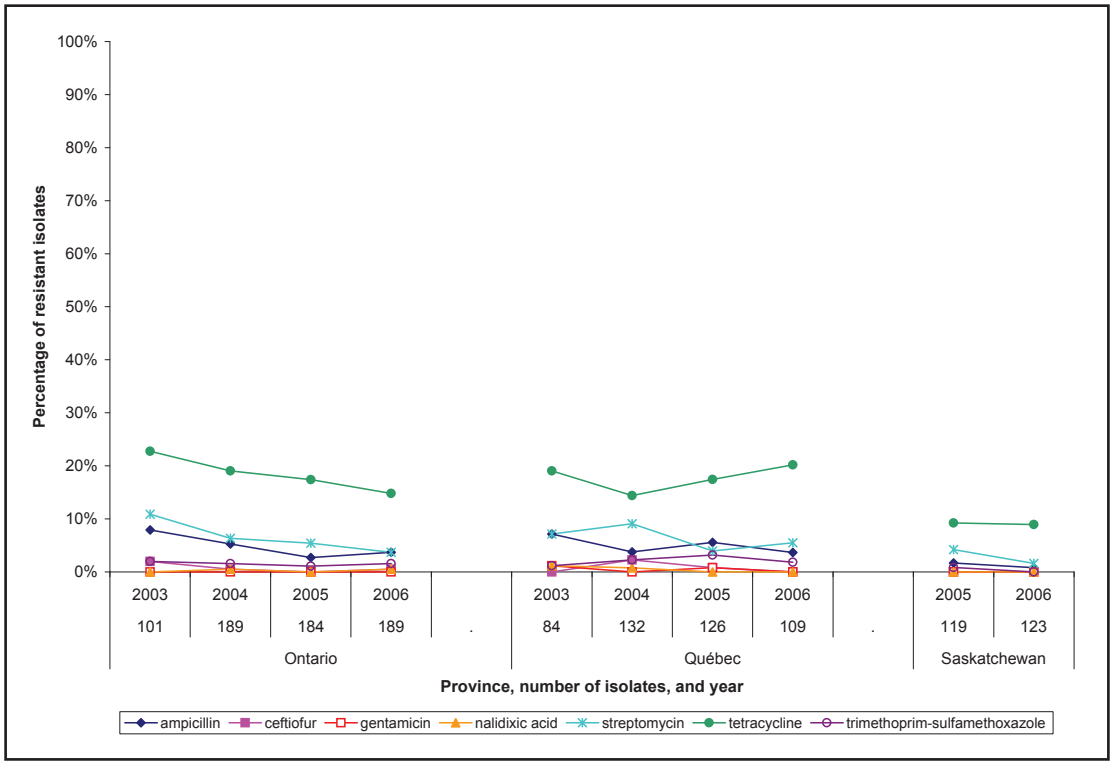


Figure 13. Temporal variation of the resistance to selected antimicrobials of beef *E. coli* isolates; *Retail Meat Surveillance*, 2003-2006.



Pork – Generic *E. coli*

(N=288; Saskatchewan n=49; Ontario n=182; Québec n=57)

Recovery: Overall, generic *E. coli* isolates were recovered from 40% (288/727) of retail pork samples. Provincial recovery rates were 31% (49/156) in isolates from Saskatchewan, 60% (182/311) in isolates from Ontario, and 21% (57/270) in isolates from Québec (Table 65, Appendix B.3). The recovery rates in Saskatchewan and Québec were significantly lower than in Ontario, and the rate in Québec was also significantly lower than in Saskatchewan. This difference between Ontario and Québec has been observed since 2003. Similar to beef generic *E. coli*, this difference cannot be explained by differences in laboratory methods, sampling protocols, or transport conditions.

Antimicrobial Drug Resistance: See Figure 14 and Table 50 (Appendix B. 2). Resistance to one or more antimicrobials was detected in 37% (18/49) of the isolates from Saskatchewan, 53% (96/182) of the isolates from Ontario, and 42% (24/57) of the isolates from Québec. Across the three provinces, no isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or nalidixic acid. No isolates had reduced susceptibility to ciprofloxacin. Resistance to amoxicillin-clavulanic acid (1%, 2/182) and ceftiofur (1%, 1/182) were detected among Ontario isolates. There was no significant difference between the provinces in terms of prevalence of resistance for any of the antimicrobials tested.

AMR Patterns: Across the three provinces, the most frequent patterns were resistance to tetracycline alone (8%, 24/288), CHL-SSS-TET (5%, 13/288), and AMP-TET (4%, 11/288). The ACSSuT (2%, 6/288), AKSSuT (1%, 4/288), and A2C-AMP (<1%, 1/288) patterns were also observed. Resistance to five or more antimicrobials was detected in 5% (15/288) of the isolates.

Temporal Variations: See Figure 15. Between 2003 and 2006 in Ontario and Québec and between 2005 and 2006 in Saskatchewan, no significant changes were identified.

In 2006, among *E. coli* isolates from retail pork, the ACSSuT, AKSSuT, and A2C-AMP patterns were observed in 2% (6/288), 1% (4/288) and less than 1% (1/288) of the isolates respectively. Between 2003 (2005 in Saskatchewan) and 2006, no significant temporal changes in resistance were identified.

Figure 14. Individual antimicrobial drug resistance in pork *E. coli* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

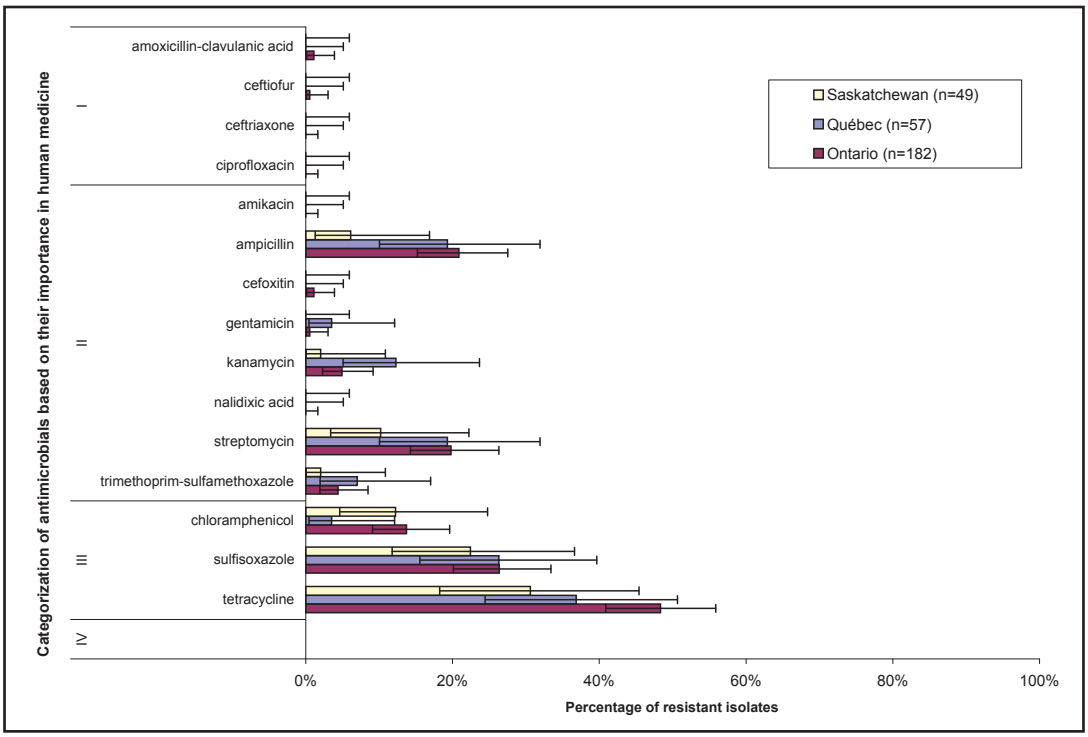
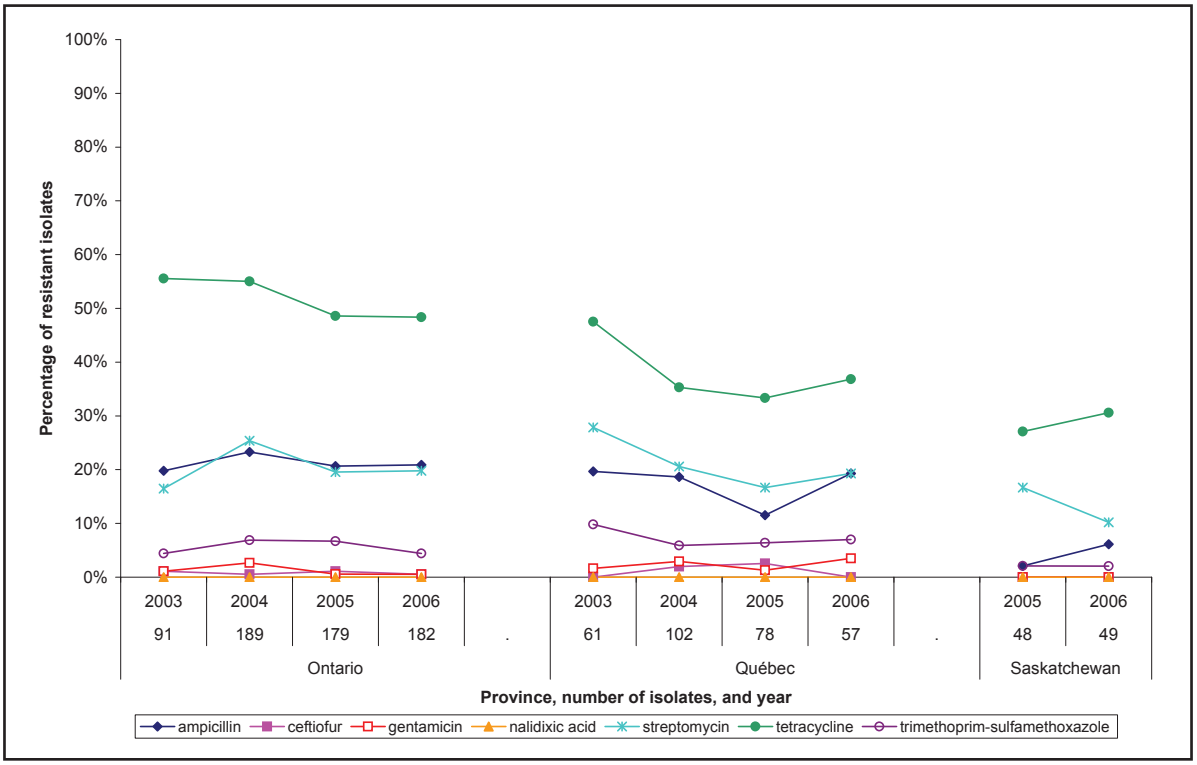


Figure 15. Temporal variation of the resistance to selected antimicrobials of pork *E. coli* isolates; *Retail Meat Surveillance*, 2003-2006.



Chicken – Generic *E. coli*

(N=372; Saskatchewan n=85; Ontario n=152; Québec n=135)

Recovery: Overall, generic *E. coli* isolates were recovered from 96% (372/386) of retail chicken samples. Provincial recovery rates were 99% (85/86) in Saskatchewan, 97% (152/156) in Ontario, and 94% (135/144) in Québec (Table 65, Appendix B.3).

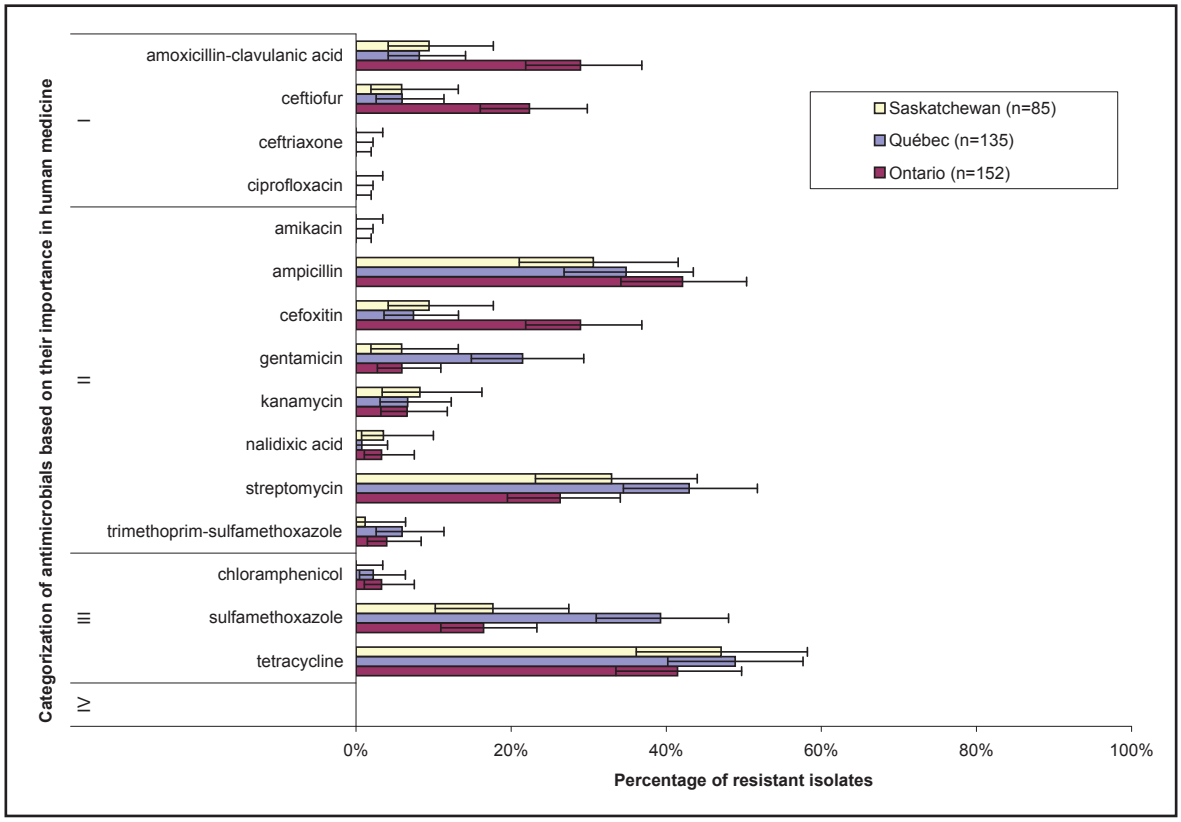
Antimicrobial Drug Resistance: See Figure 16 and Table 51 (Appendix B. 2). Resistance to one or more antimicrobials was detected in 65% (55/85) of the isolates from Saskatchewan, 67% (102/152) of the isolates from Ontario, and 69% (93/135) of the isolates from Québec. Across the three provinces, no isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. Resistance to amoxicillin-clavulanic acid (29%, 44/152), ceftiofur (22%, 34/152), and cefoxitin (29%, 44/152) was significantly higher in Ontario than in Saskatchewan (9%, 8/85; 6%, 5/85; and 9%, 8/85 respectively), and Québec (8%, 11/135; 6%, 8/135; and 7%, 10/135 respectively). In Ontario, intermediate susceptibility to ceftriaxone and resistance to nalidixic acid and reduced susceptibility to ciprofloxacin were observed in 10% (15/152) and 3% (5/152) and 3% (5/152) of the isolates, respectively. One of these isolates had both intermediate susceptibility to ceftriaxone and resistance to nalidixic acid. Intermediate susceptibility to ceftriaxone (2%, 3/135; 1%, 1/85) and resistance to nalidixic acid (1%, 1/135; 4%, 3/85), and reduced susceptibility to ciprofloxacin (1%, 1/135; 4%, 3/85) were also observed in Québec and Saskatchewan, respectively.

AMR Patterns: Across the three provinces, the most frequent patterns were resistance to tetracycline alone (8%, 29/372), STR-TET (6%, 21/372), and A2C-AMP alone (5%, 20/372). The A2C-AMP pattern was additionally observed with resistance to other antimicrobials in 11% (40/372) of the isolates. The AKSSuT (1%, 5/372), A2C-ACSSuT (1%, 4/372), A2C-ACKSSuT (<1% (1/372), A2C-AKSSUT (<1% (1/372), and ACSSuT (<1% (1/372) patterns were also observed. Resistance to five or more antimicrobials was detected in 13% (48/372) of the isolates.

Temporal Variations: See Figure 17. Between 2004[13] and 2006, there was a significant decrease in ceftiofur and ampicillin resistance in Québec. No significant changes were found in Saskatchewan or Ontario.

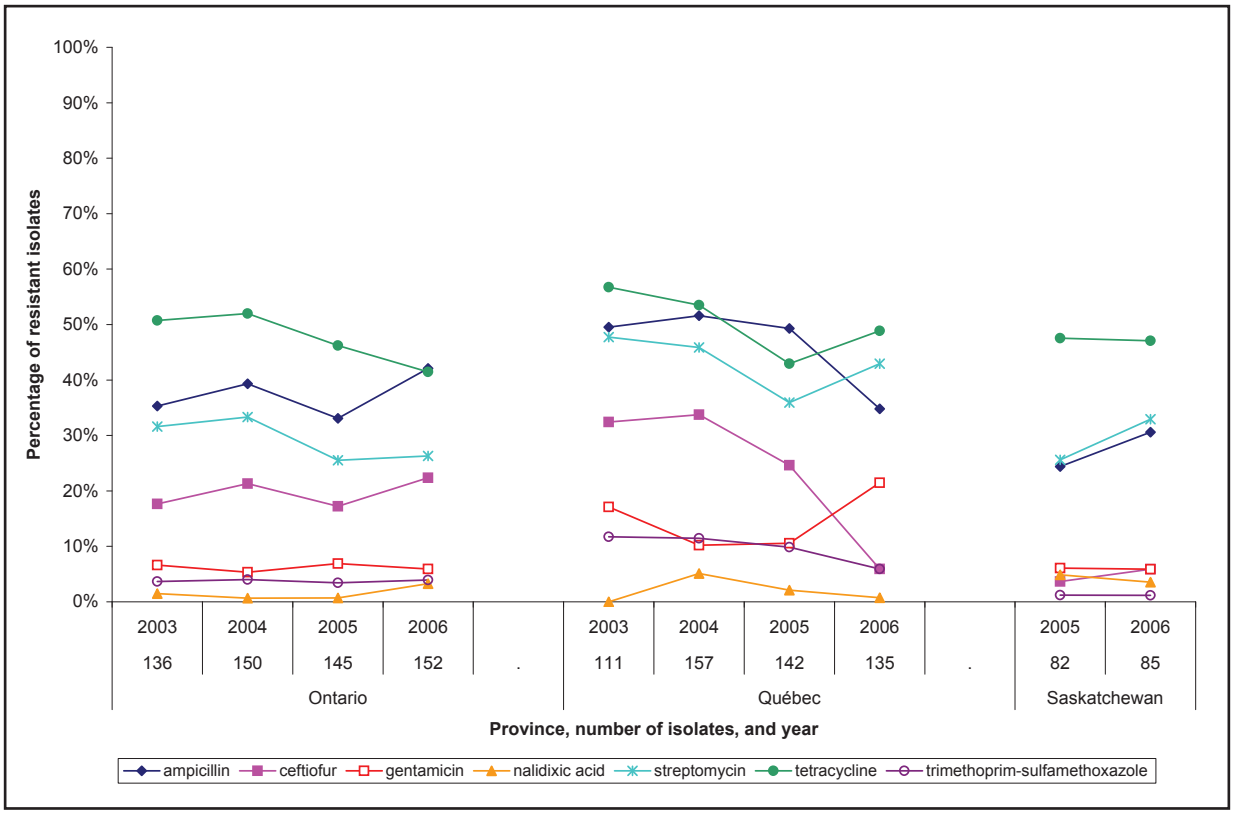
In 2006, among retail chicken *E. coli* isolates, resistance to amoxicillin-clavulanic acid (29%, 44/152), ceftiofur (22%, 34/152), and cefoxitin (29%, 44/152) was significantly higher in Ontario than in Saskatchewan (9%, 8/85; 6%, 5/85; and 9%, 8/85 respectively), and Québec (8%, 11/135; 6%, 8/135;and 7%, 10/135 respectively). Between 2004 and 2006, there was a significant decrease of resistance to ceftiofur and ampicillin in isolates from Québec.

Figure 16. Individual antimicrobial drug resistance in chicken *E. coli* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.



[13] 2004 was selected as the year of reference/comparison for amoxicillin-clavulanic acid, ceftiofur, cefoxitin, and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Figure 17. Temporal variation of the resistance to selected antimicrobials of chicken *E. coli* isolates; *Retail Meat Surveillance*, 2003-2006.



Chicken – *Salmonella*

(N=94; Saskatchewan n=25; Ontario n=36; Québec n=33)

Recovery: In 2006, *Salmonella* isolates were recovered from 13% (94/735) of retail chicken samples overall. Provincial recovery rates were 16% (25/153) in Saskatchewan, 12% (36/311) in Ontario, and 12% (33/288) in Québec (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 18, Table 13, and Table 52 (Appendix B. 2). Resistance to one or more antimicrobials was detected in 44% (11/25) of the isolates from Saskatchewan, in 42% (15/36) of the isolates from Ontario, and 55% (18/33) of the isolate from Québec. Across the three provinces, no isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin, or nalidixic acid. No isolates had reduced susceptibility to ciprofloxacin. Resistance to amoxicillin-clavulanic acid and ceftiofur were each observed in one isolate from Saskatchewan, 14% (5/36) of the isolates from Ontario, and 9% (3/33) of the isolates from Québec. Intermediate susceptibility to ceftriaxone was observed in one isolate from Saskatchewan, in 8% (3/36) of Ontario isolates, and in 6% (2/33) of Québec isolates, and in. There was no significant difference between the provinces in terms of prevalence of resistance for any of the antimicrobials tested.

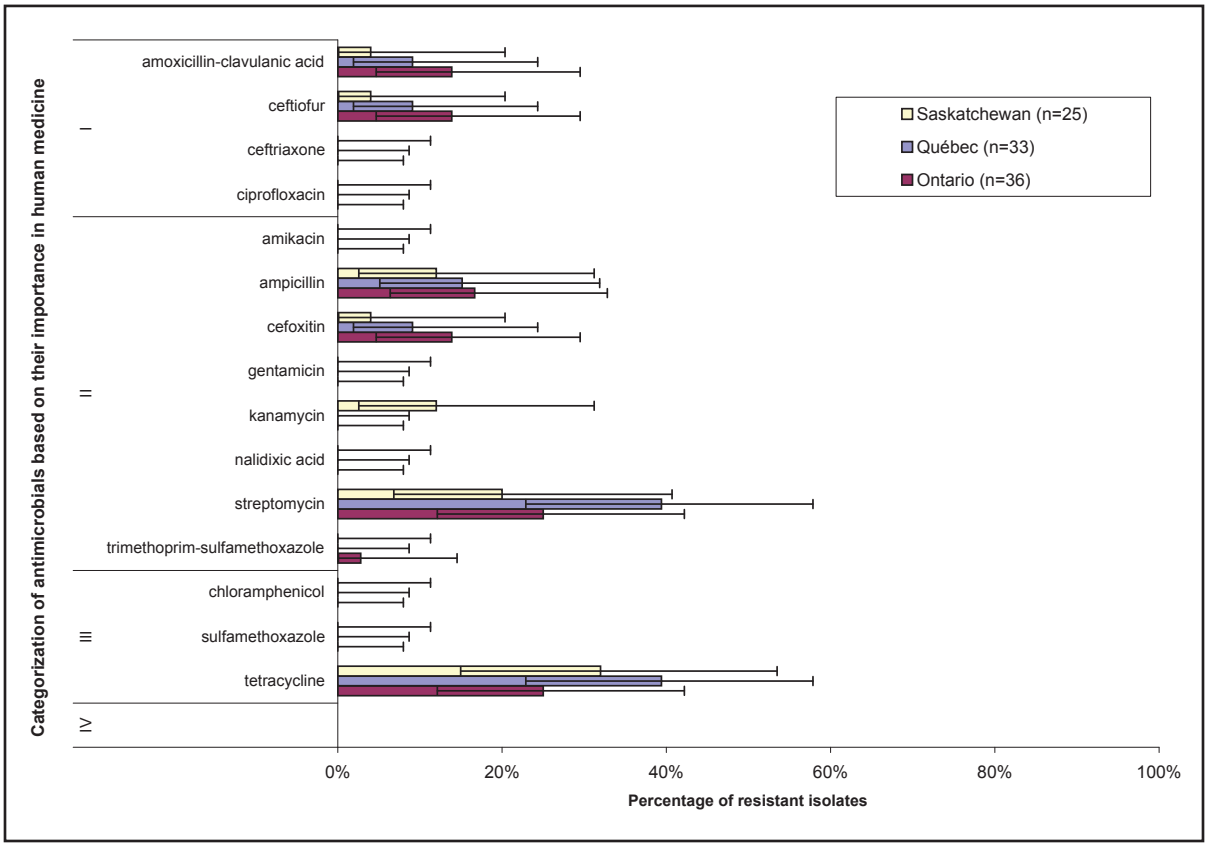
AMR Patterns: Across the three provinces, the most frequent pattern was resistance to STR-TET (21%, 20/94), tetracycline alone (7%, 7/94), and A2C-AMP alone (7%, 7/94). The A2C-AMP pattern (with or without resistance to other antimicrobials) was observed in 10% (9/94) of the isolates, including six isolates with intermediate susceptibility to ceftriaxone. Resistance to five or more antimicrobials was detected in 2% (2/94) of the isolates.

Serovars: See Table 13. The most frequent *Salmonella* serovars were Heidelberg (38%, 36/94), Kentucky (22%, 21/94), and Enteritidis (11%, 10/94). Resistance to five or more antimicrobials was detected in one S. Kentucky isolate from Ontario, and one S. Heidelberg isolate from Saskatchewan.

Temporal Variations: See Figure 19. Between 2004[14] and 2006, ceftiofur and ampicillin resistance significantly decreased in Ontario and Québec. No significant trends were found in Saskatchewan.

Between 2004 and 2006, a significant decrease in ceftiofur and ampicillin resistance was found in retail chicken *Salmonella* isolates from Ontario and Québec.

Figure 18. Individual antimicrobial drug resistance in chicken *Salmonella* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

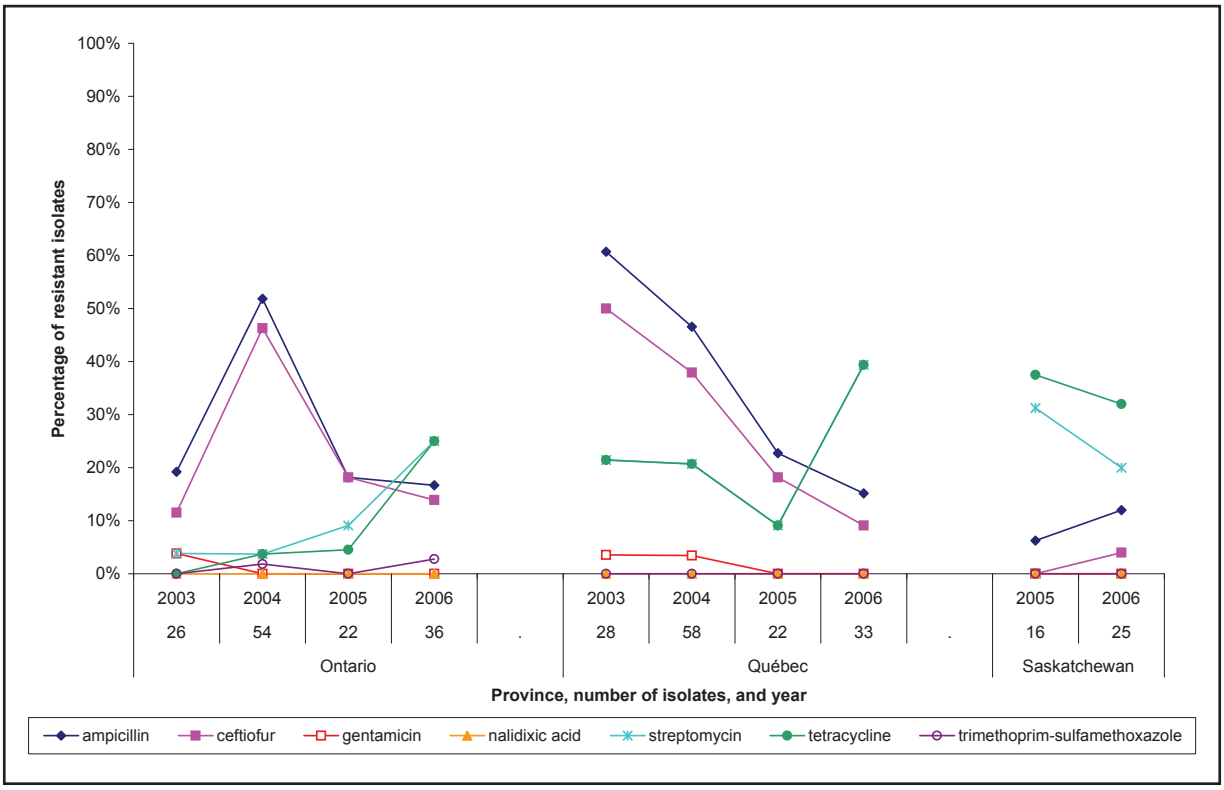


[14] 2004 was selected as the year of reference/comparison for amoxicillin-clavulanic acid, ceftiofur, cefoxitin, and ampicillin resistance because of a change in ceftiofur use practices by Québec chicken hatcheries in early 2005.

Table 13. Number of antimicrobials in resistance pattern of chicken *Salmonella* isolates across serovars; *Retail Meat Surveillance*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Saskatchewan					
Heidelberg	8 (32)	5	2	1	0
Enteritidis	5 (20)	5	0	0	0
Hadar	5 (20)	0	5	0	0
Kiambu	3 (12)	2	1	0	0
I 4:i:-	1 (4)	0	1	0	0
Infantis	1 (4)	1	0	0	0
Kentucky	1 (4)	0	1	0	0
Thompson	1 (4)	1	0	0	0
Total	**25 (100)**	**14**	**10**	**1**	**0**
Ontario					
Heidelberg	14 (38.9)	10	4	0	0
Kentucky	8 (22.2)	2	5	1	0
Enteritidis	3 (8.3)	3	0	0	0
Indiana	3 (8.3)	2	1	0	0
Albert	1 (2.8)	0	1	0	0
I 6,8:-:x	1 (2.8)	0	1	0	0
I 8,20:i:-	1 (2.8)	0	1	0	0
Kiambu	1 (2.8)	1	0	0	0
Putten	1 (2.8)	0	1	0	0
Thompson	1 (2.8)	1	0	0	0
Typhimurium	1 (2.8)	1	0	0	0
Typhimurium var. 5-	1 (2.8)	1	0	0	0
Total	**36 (100)**	**21**	**14**	**1**	**0**
Québec					
Heidelberg	14 (42.4)	10	4	0	0
Kentucky	12 (36.4)	2	10	0	0
Enteritidis	2 (6.1)	2	0	0	0
Typhimurium var. 5-	2 (6.1)	0	2	0	0
Hadar	1 (3)	0	1	0	0
I 8,20:i:-	1 (3)	0	1	0	0
Thompson	1 (3)	1	0	0	0
Total	**33 (100)**	**15**	**18**	**0**	**0**
Grand total	**94 (100)**	**50**	**42**	**2**	**0**

Figure 19. Temporal variation of the resistance to selected antimicrobials of chicken *Salmonella* isolates; *Retail Meat Surveillance*, 2003-2006.



Chicken – *Campylobacter*

(N=255; Saskatchewan n=51; Ontario n=104; Québec n=100)

Recovery: Overall, *Campylobacter* isolates were recovered from 35% (255/735) of retail chicken samples. Provincial recovery rates were 33% (51/155) in Saskatchewan, 34% (104/311) in Ontario, and 36% (100/288) in Québec (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 20, Figure 21, Table 14, and Table 53 (Appendix B.2). Resistance to one or more antimicrobials was detected in 35% (18/51) of the Saskatchewan isolates, 58% (60/104) of the Ontario isolates, and 67% (67/100) of the Québec isolates. No isolates were resistant to gentamicin or non-susceptible to florfenicol. Additionally, no isolates from Saskatchewan or Québec were resistant to clindamycin. Resistance to ciprofloxacin and nalidixic acid was found in one isolate from Saskatchewan, in 3% (3/104) of Ontario isolates, and in 2% (2/100) of Québec isolates. Resistance to tetracycline was significantly lower in Saskatchewan (35%, 18/51) than in Québec (66%, 66/100). Resistance to both ciprofloxacin and nalidixic acid was observed in 1% (3/202) of *C. jejuni* isolates and 6% (3/52) *C. coli* isolates. Resistance to nalidixic acid and ciprofloxacin was not detected in *Campylobacter* spp. isolates.

AMR Patterns: Across the three provinces, the most frequent patterns were resistance to tetracycline alone (49%, 124/255) and AZM-ERY-TET (3%, 8/255). The third most frequent resistance pattern across the three provinces was CIP-NAL-TET (2%, 6/255). Resistance to three or more antimicrobials was detected in 7% (19/255) of the isolates.

Temporal Variations: See Figure 22. Between 2003 and 2006, there was a significant decrease in azithromycin resistance in Québec. No significant trends were identified in Saskatchewan or Ontario.

In 2006, among retail chicken *Campylobacter* isolates, resistance was detected to ciprofloxacin and nalidixic acid in one isolate from Saskatchewan, in 3% (3/104) of the Ontario isolates, and in 2% (2/100) of the Québec isolates. Across all three provinces, the most frequent patterns were resistance to tetracycline alone (49%, 124/255) and to AZM-ERY-TET (3%, 8/255). Between 2003 and 2006, there was a significant decrease in azithromycin resistance in Québec.

Figure 20. Individual antimicrobial drug resistance in chicken *Campylobacter* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

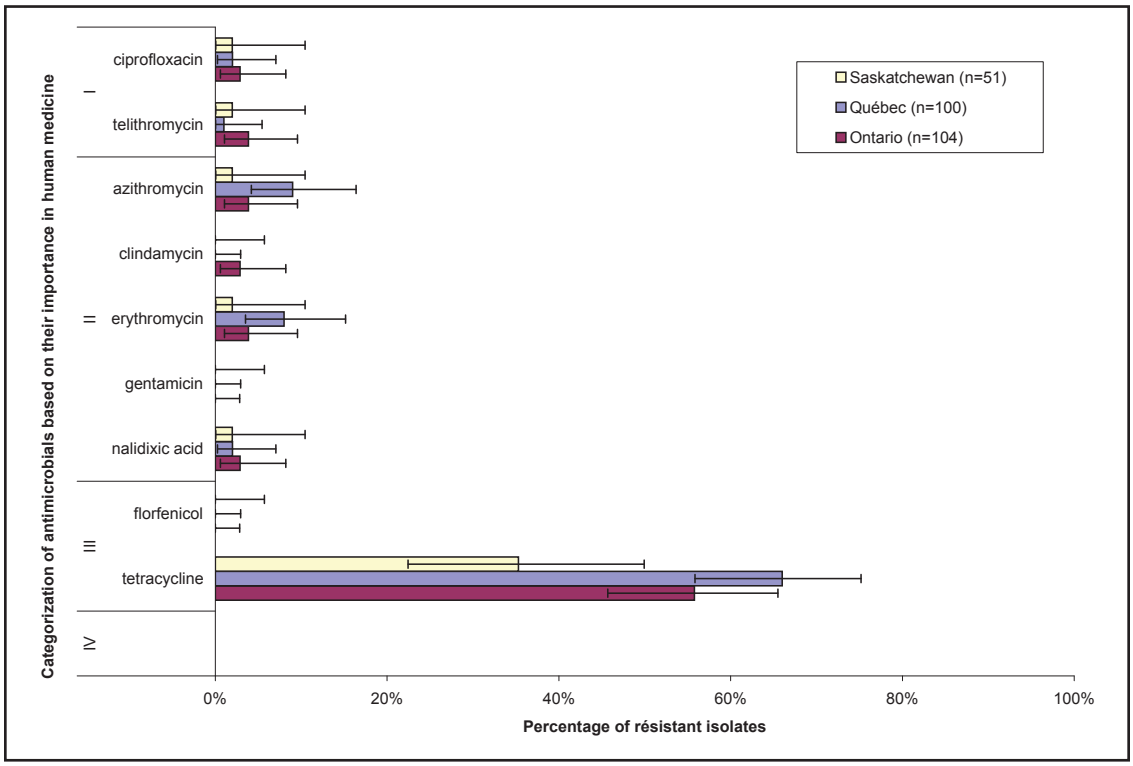


Figure 21. Individual antimicrobial drug resistance in chicken *Campylobacter* isolates across *Campylobacter* species, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

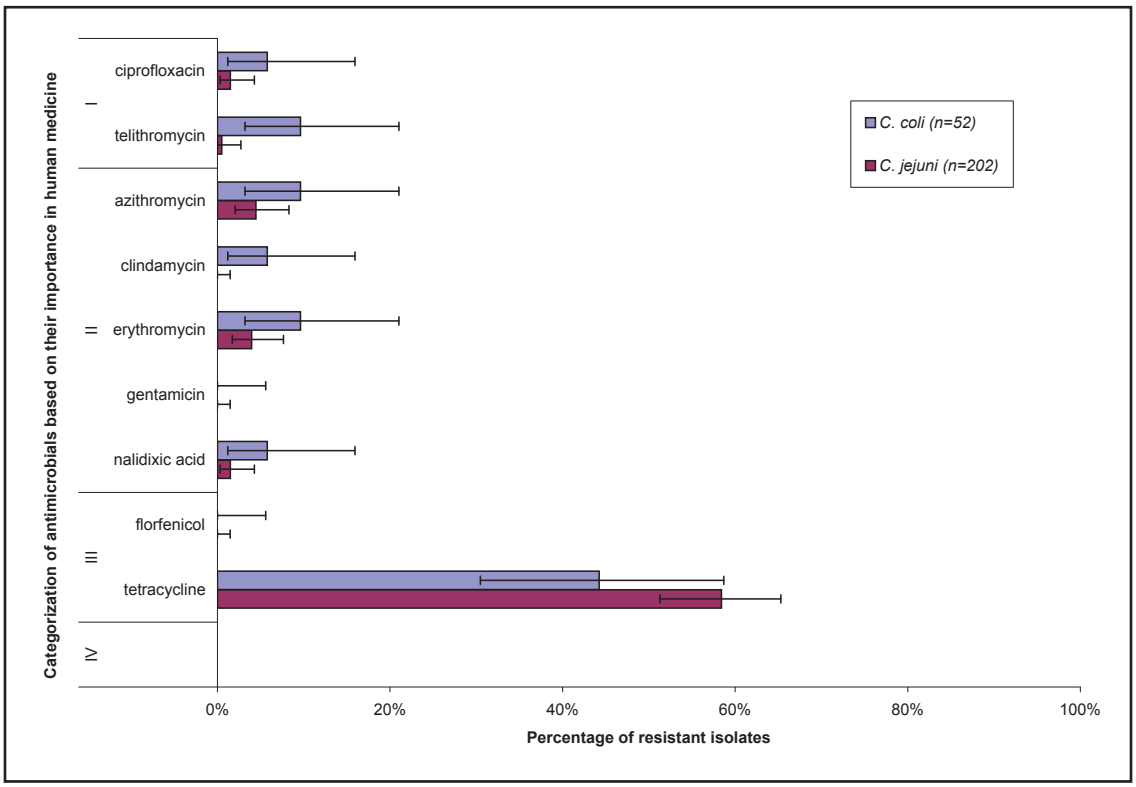
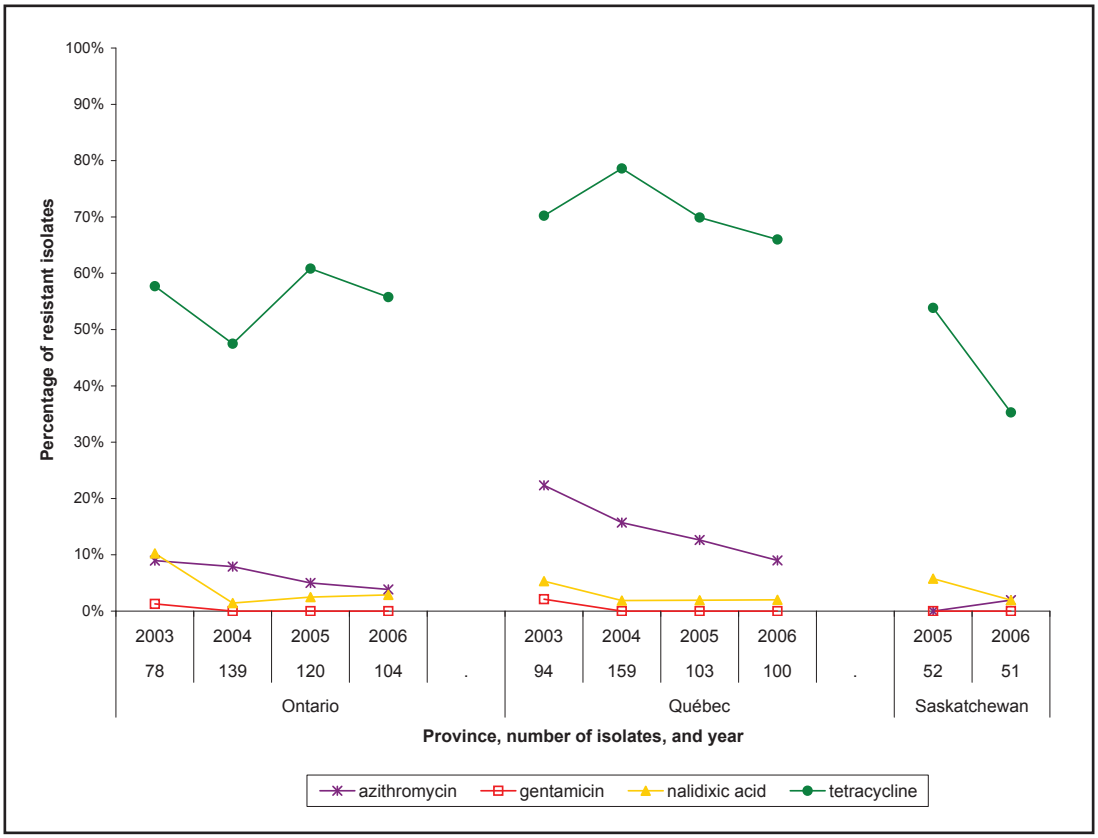


Table 14. Number of antimicrobials in resistance pattern of chicken *Campylobacter* isolates across species; *Retail Meat Surveillance*, 2006.

Species	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-2	3-4	5-9
		Number of isolates			
Saskatchewan					
C. jejuni	40 (78.4)	23	17	0	0
C. coli	11 (21.6)	10	1	0	0
Total	**51 (100)**	**33**	**18**	**0**	**0**
Ontario					
C. jejuni	87 (83.7)	36	51	0	0
C. coli	17 (16.3)	8	7	2	0
Total	**104 (100)**	**44**	**58**	**2**	**0**
Québec					
C. jejuni	75 (75)	24	51	0	0
C. coli	24 (24)	9	15	0	0
Campylobacter spp.	1 (1)	0	1	0	0
Total	**100 (100)**	**33**	**67**	**0**	**0**
Grand Total	**255 (100)**	**110**	**143**	**2**	**0**

Figure 22. Temporal variation of the resistance to selected antimicrobials of chicken *Campylobacter* isolates; *Retail Meat Surveillance*, 2003-2006.



Chicken - *Enterococcus*

(N=382; Saskatchewan n=85; Ontario n=154; Québec n=143[15])

Recovery: Overall, *Enterococcus* isolates were recovered from 99% (383/387) of chicken retail meat samples. Provincial recovery rates were 98% (85/87) in Saskatchewan, 99% (154/156) in Ontario, and 100% (144/144) in Québec (Table 65, Appendix B.3).

Antimicrobial Drug Resistance: See Figure 23, Figure 24, Table 15, and Table 54 (Appendix B.2). Resistance to one or more antimicrobials was detected in 93% (79/85) of the isolates from Saskatchewan, 95% (147/154) of the isolates from Ontario, and 92% (132/143) of the isolates from Québec. Across the three provinces, no isolates were non-susceptible to daptomycin or were resistant to linezolid or vancomycin. Resistance to ciprofloxacin was detected in 4% (3/85) of the Saskatchewan isolates, in one isolate from Ontario, but was not detected in isolates from Québec. Ciprofloxacin resistance was observed in *E. faecium* (30%, 3/10) and *Enterococcus* spp. (10%, 1/10) isolates. Among *E. faecium* and *Enterococcus* spp. isolates, quinupristin-dalfopristin resistance was detected in 40% (2/5) of the isolates from Saskatchewan, 57% (4/7) of the isolates from Ontario, and 63% (5/8) of the isolates from Québec. There was no significant difference between the provinces in terms of prevalence of resistance for any of the antimicrobials tested, with the exception of streptomycin where resistance was higher in Québec (34%, 49/143) than in Ontario (18%, 29/154).

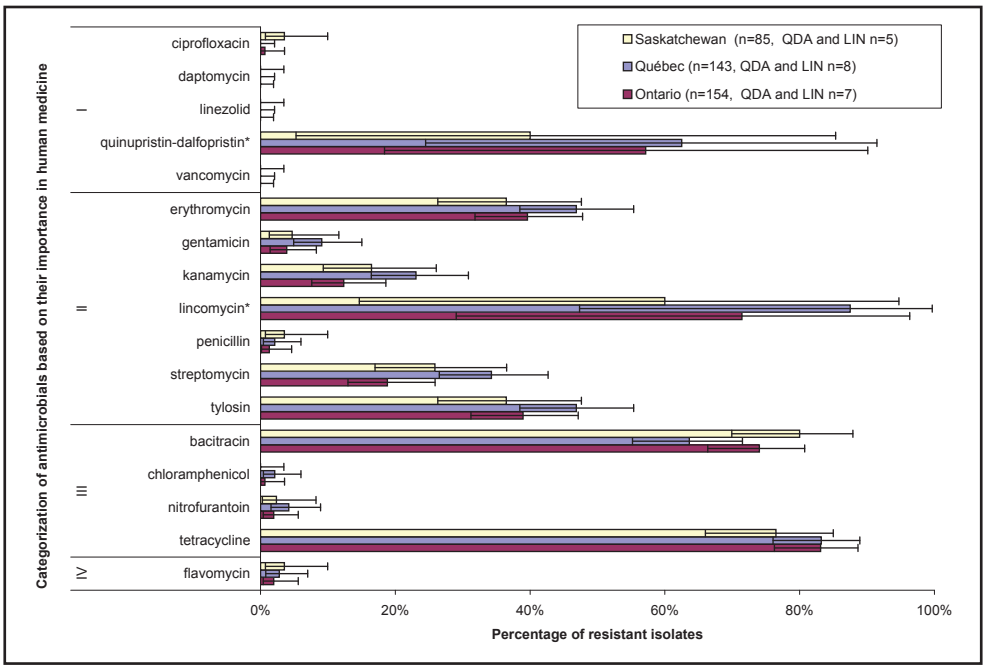
AMR Patterns: Across the three provinces, the most frequent pattern was resistance to BAC-TET (Saskatchewan; 31%, 26/85; Ontario: 33%, 51/154; and Québec: 24%, 35/143), followed by resistance to BAC-ERY-TET-TYL (Saskatchewan; 5%, 4/85; Ontario: 18%, 27/154; and Québec: 11%, 16/143). Resistance to five or more antimicrobials was detected in 25% (21/85) of the Saskatchewan isolates, 18% (27/154) of the Ontario isolates, and 28% (40/143) of the Québec isolates.

[15] One of the 144 isolates could not be submitted for AMR testing because of the absence of growth once inoculated onto the test plate.

Temporal Variations: See Figure 25. Between 2003 and 2006, bacitracin resistance significantly decreased in Ontario and Québec. Tylosin and erythromycin resistance decreased in Québec and tetracycline resistance decreased in Saskatchewan.

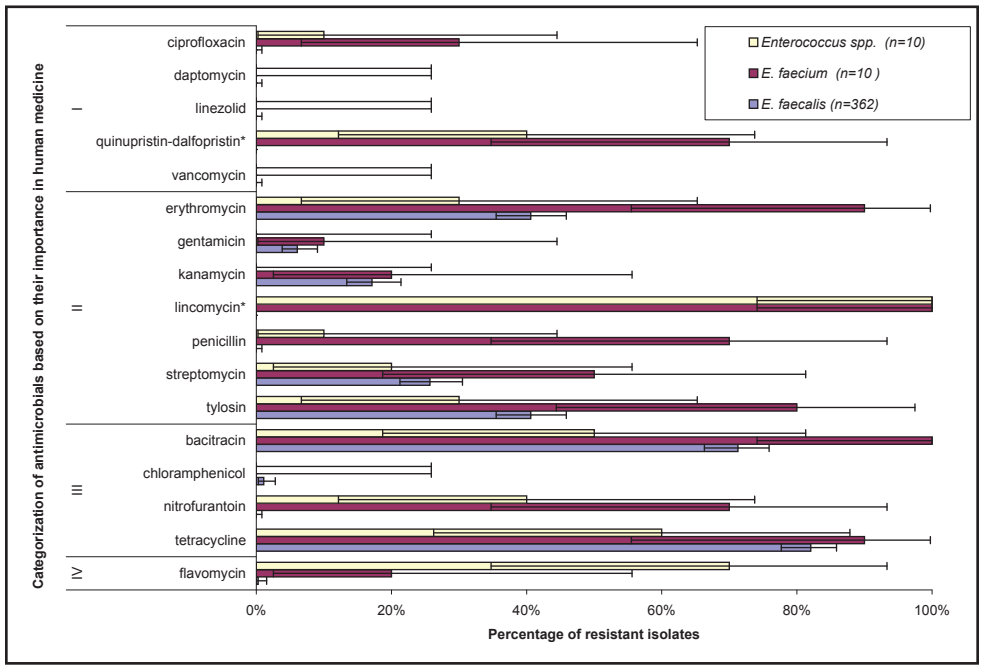
In 2006, among retail chicken *Enterococcus* isolates, resistance to ciprofloxacin was detected 4% (3/85) of the Saskatchewan isolates, in one Ontario isolate, and was not detected in Québec. Ciprofloxacin-resistant isolates were *E. faecium* (30%, 3/10) and *Enterococcus* spp. (10%, 1/10). Between 2003 and 2006, bacitracin resistance significantly decreased in Ontario and Québec. Tylosin and erythromycin resistance decreased in Québec and tetracycline resistance decreased in Saskatchewan.

Figure 23. Individual antimicrobial drug resistance in chicken *Enterococcus* isolates from Saskatchewan, Ontario, and Québec, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.



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

Figure 24. Individual antimicrobial drug resistance in chicken *Enterococcus* isolates across Enterococcus species, including 95% confidence intervals; *Retail Meat Surveillance*, 2006.

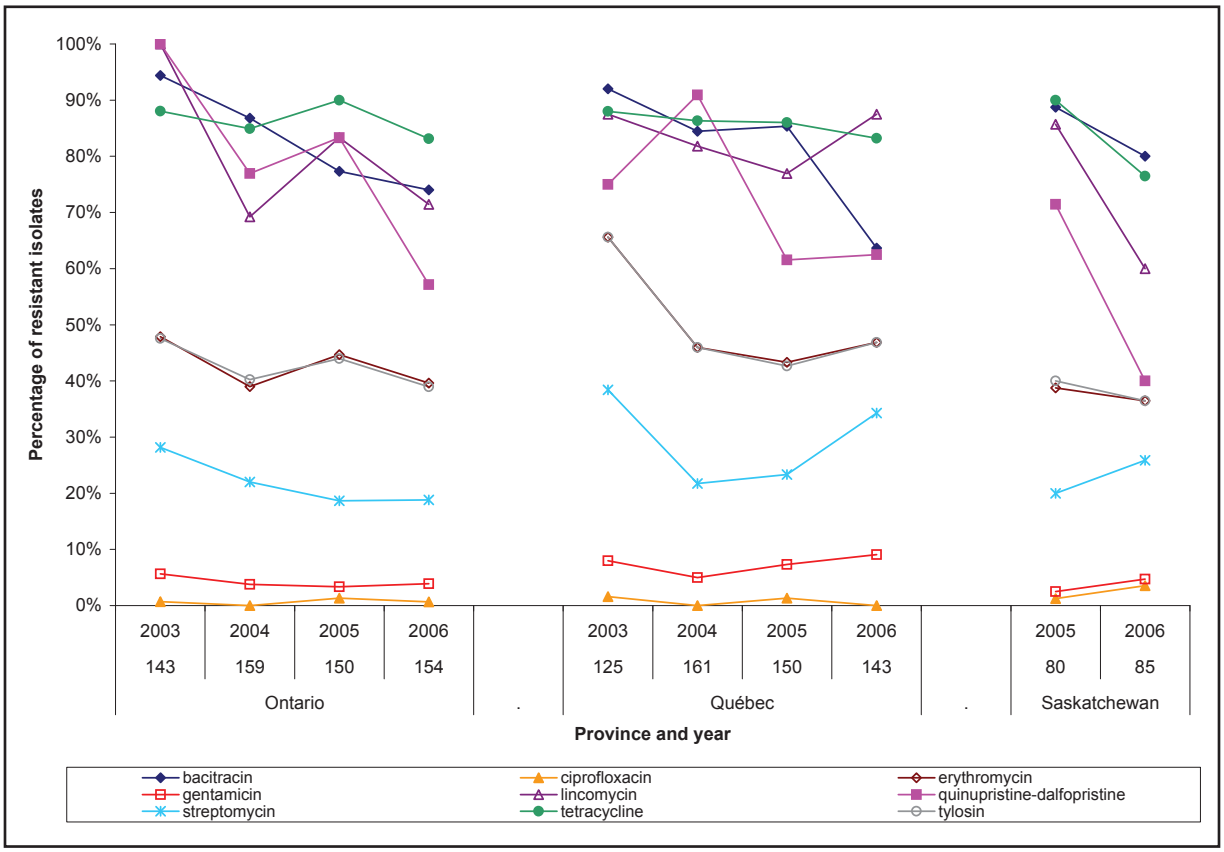


Note: Resistance to quinupristin-dalfopristin (QDA) and lincomycin (LIN) is not reported for *E. faecalis* as it is intrinsically resistant to these antimicrobials.

Table 15. Number of antimicrobials in resistance pattern of chicken *Enterococcus* isolates across species; *Retail Meat Surveillance*, 2006.

Species	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Saskatchewan					
E. faecalis	80 (94.1)	6	56	18	0
Enterococcus spp.	3 (3.5)	0	2	1	0
E. faecium	2 (2.4)	0	0	1	1
Total	**85 (100)**	**6**	**58**	**20**	**1**
Ontario					
E. faecalis	147 (95.5)	7	118	22	0
E. faecium	4 (2.6)	0	1	1	2
Enterococcus spp.	3 (1.9)	0	1	2	0
Total	**154 (100)**	**7**	**120**	**25**	**2**
Québec					
E. faecalis	136 (94.4)	11	90	34	0
E. faecium	4 (2.8)	0	0	1	3
Enterococcus spp.	4 (2.8)	0	2	2	0
Total	**143 (100)**	**11**	**92**	**37**	**3**
Grand Total	**382 (100)**	**24**	**270**	**82**	**6**

Figure 25. Temporal variation of the resistance to selected antimicrobials of chicken *Enterococcus* isolates; *Retail Meat Surveillance*, 2003-2006.



Box 2. Retail sampling in British Columbia, *CIPARS*, 2006.

In an effort to expand the national scope of the retail meat component of CIPARS, some preliminary retail meat sampling pilots were conducted in British Columbia in 2003, 2005, and 2006. A summary of the recovery and antimicrobial resistance results for those three pilots is presented here.

Table A. Overall recovery rates from retail meat pilot sampling in British Columbia in 2003, 2005, and 2006

Commodity	*E. coli*	*Salmonella*	*Campylobacter*	*Enterococcus*
Beef	34/43 (79%)	0/8 (0%)	0/8 (0%)	4/8 (50%)
Pork	15/48 (31%)	0/8 (0%)	0/8 (0%)	6/8 (75%)
Chicken	31/32 (75%)	5/55 (9%)	35/55 (64%)	31/32 (97%)

Table B. Individual antimicrobial drug resistance in *E. coli, Salmonella, Campylobacter,* and *Enterococcus* isolates from British Columbia (Percent of resistant isolates).

		E. coli			*Salmonella*	*Campylobacter*	*Enterococcus*		
	Number tested[1]	Beef 34	Chicken 31	Pork 15	Chicken 5	Chicken 35*	Beef 4	Chicken 31	Pork 6
	Antimicrobial								
I	amoxicillin-clavulanic acid	0%	45%	20%	20%				
I	ceftiofur	0%	35%	20%	20%				
I	ceftriaxone	0%	0%	0%	20%				
I	ciprofloxacin	0%	0%	0%	0%	11%	0%	3%	0%
I	daptomycin						NT	0% (0/24)	NT
I	linezolid						0%	3%	0%
I	quinupristin-dalfopristin						50% (1/2)	0% (0/1)	NT
I	telithromycin					0% (0/5)			
I	vancomycin						0%	0%	0%
II	amikacin	0%	0%	0%	0%				
II	ampicillin	0%	68%	27%	20%				
II	azythromycin					0%			
II	cefoxitin	0%	45%	20%	20%				
II	clindamycin					0%			
II	erythromycin					0%	25%	35%	0%
II	gentamicin	0%	3%	7%	0%	0%	0%	0%	0%
II	kanamycin	0%	29%	0%	0%		0%	6%	0%
II	lincomycin						50% (1/2)	100% (1/1)	NT
II	nalidixic acid	0%	3%	7%	0%	11%			
II	penicillin						0%	0%	0%
II	streptomycin	6%	42%	20%	20%		0%	13%	0%
II	trimethoprim-sulfamethoxazole	0%	6%	0%	0%				
II	tylosin						25%	32%	0%
III	bacitracin						75%	87%	67%
III	chloramphenicol	6%	10%	13%	0%	0%	0%	3%	0%
III	florphenicol					0% (0/5)			
III	nitrofurantoin						0%	0%	0%
III	salinomycin						0%	0% (0/7)	0%
III	sulfamethoxazole	9%	32%	33%	0%				
III	tetracycline	32%	71%	33%	20%	57%	50%	97%	67%
IV	flavomycin						50%	3%	0%

Note: Antimicrobials are classified according to their importance in human medicine. NT=not tested.

[1] Number of isolates tested can vary across antimicrobials due to changes in testing plate from 2003 to 2006. For *Enterococcus*, only *E. faecium* is tested for lincomycin and quinupristin-dalfopristin resistance as *E. faecalis* is intrinsically resistant to these antimicrobials. The actual number of isolates tested is mentioned between brackets when it differs from numbers indicated in the column heading.

More details on the data presented in this text box can be provided upon request at cipars-picra@phac-aspc.gc.ca. As retail sampling activities in British Columbia were continued in 2007, results from the 2007 sampling year will be published in the 2007 CIPARS Annual Report.

Part III – On-Farm Surveillance

Swine - Generic *E. coli*
(N=2197)

Recovery: Generic *E. coli* isolates were recovered from 99% (459/462) of swine fecal samples. Up to five isolates per sample were tested for antimicrobial resistance.

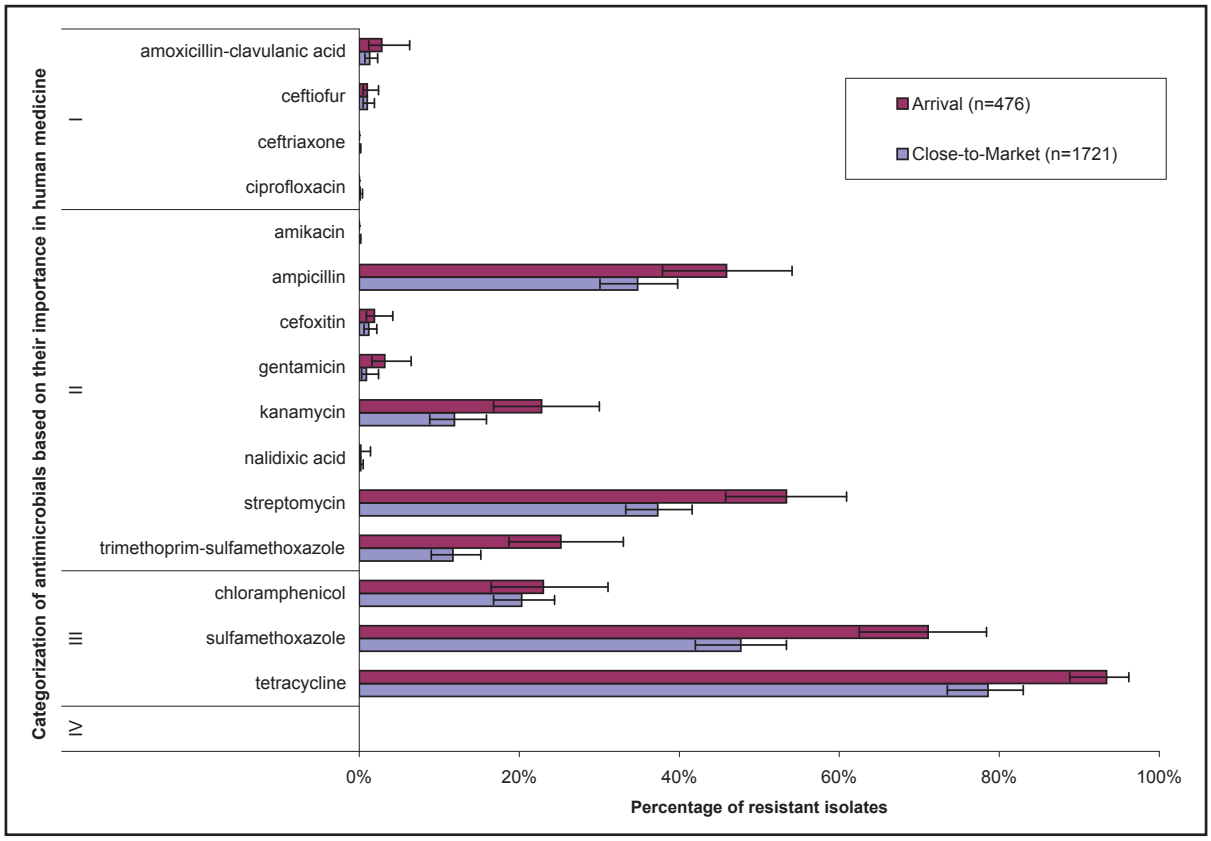
Antimicrobial Drug Resistance: See Figure 26 and Table 55 (Appendix B.2). Resistance to one or more antimicrobials was detected in 87% (1905/2197) of all the isolates. No close-to-market isolates were resistant to ceftriaxone or amikacin. No arrival isolates were resistant to ceftriaxone, ciprofloxacin, or amikacin. Among all the isolates, amoxicillin-clavulanic acid resistance was found in 2% (35/2197) of the isolates, ceftiofur resistance was found in 1% (22/2197) of the isolates, and one isolate was resistant to ciprofloxacin. Intermediate susceptibility to ceftriaxone was found in less than 1% (11/2197) of all the isolates. No reduced susceptibility to ciprofloxacin was observed. Resistance to ampicillin, streptomycin, sulfamethoxazole, tetracycline, and trimethoprim-sulfamethoxazole was significantly lower among E. coli isolates recovered from close-to-market hogs as compared to hogs at arrival in the growing-finishing phase[16].

AMR Patterns: The most frequent patterns observed across all isolates were resistance to tetracycline alone (14%, 307/2197), STR-TET (5%, 117/2197), and STR-SSS-TET (5%, 107/2197). Resistance to five or more antimicrobials was detected in 15% (328/2197) of all the isolates. Resistance to ACSSuT, AKSSuT, and ACKSSuT was detected in 4% (84/2197), 3% (69/2197) and 2% (33/2197) of all isolates, respectively. Less than 1% of all isolates had the A2C (11/2197), A2C-ACSSuT (9/2197), and A2C-ACKSSuT (2/2197) patterns.

In 2006, among on-farm swine *E. coli* isolates, resistance was detected to amoxicillin-clavulanic acid in 2% (35/2197), ceftiofur in 1%(22/2197), and to ciprofloxacin in less than 1% (1/2197) of all the isolates. *Escherichia* coli from pigs entering the grow-finish phase of production were significantly more likely to be resistant than *E. coli* from pigs close-to-market for 5 of 7 drugs considered in the analysis.

[16] Additional information will be available in the "On-Farm Swine 2006 Antimicrobial Resistance Supplemental Report" posted on the CIPARS website in 2009 (http://www.phac-aspc.gc.ca/cipars-picra/pubs_e.html).

Figure 26. Individual antimicrobial drug resistance in swine *E. coli* isolates, corrected for clustering at the herd level, including 95% confidence intervals; *On-Farm Surveillance*, 2006.



Swine - *Salmonella*

(N=94)

Recovery: *Salmonella* isolates were recovered from 20% (94/462) of swine fecal samples.

Antimicrobial Drug Resistance: See Figure 27, Table 16, and Table 56 (Appendix B.2). Resistance to one or more antimicrobials was detected in 66% (62/94) of all isolates. No close-to-market isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, gentamicin, or nalidixic acid. No arrival isolates were resistant to amoxicillin-clavulanic acid, ceftiofur, ceftriaxone, ciprofloxacin, amikacin, cefoxitin, gentamicin, or nalidixic acid. Resistance to amoxicillin-clavulanic acid or ceftiofur was found in 1% of all the isolates (1/94). One isolate had intermediate susceptibility to ceftriaxone.

AMR Patterns: The most frequent patterns observed across all isolates were resistance to STR-SSS-TET (20%, 19/94), tetracycline alone (9%, 8/94), and ACSSuT (5%, 5/94). Resistance to five or more antimicrobials was detected in 15% (14/94) of all isolates. Five percent (5/94) of all isolates had the ACSSuT pattern, 4% (4/94) the AKSSuT pattern, 3% (3/94) the ACKSSuT pattern, and one isolate had the A2C-AMP pattern.

Serovars: See Table 16. The most frequent *Salmonella* serovars were Derby and Typhimurium var. 5-. These two serovars accounted for 36% (34/94) of all the isolates. Fifteen of the 18 Derby isolates and 14 of the 16 Typhimurium var. 5- isolates were resistant to one or more antimicrobials. Two of the 18 Derby isolates and nine of the 16 Typhimurium var. 5- isolates were resistant to five or more antimicrobials. Typhimurium accounted for 7% (7/94) of all the isolates. Four (4/7) of these isolates were resistant to one or more antimicrobials and three (3/7) were resistant to five or more antimicrobials.

In 2006, among on-farm swine *Salmonella* isolates, resistance to amoxicillin-clavulanic acid and ceftiofur was found in 1% (1/94) of all isolates. One isolate had intermediate susceptibility to ceftriaxone.

Figure 27. Individual antimicrobial drug resistance in swine *Salmonella* isolates, corrected for clustering at the herd level, including 95% confidence intervals; *On-Farm Surveillance*, 2006.

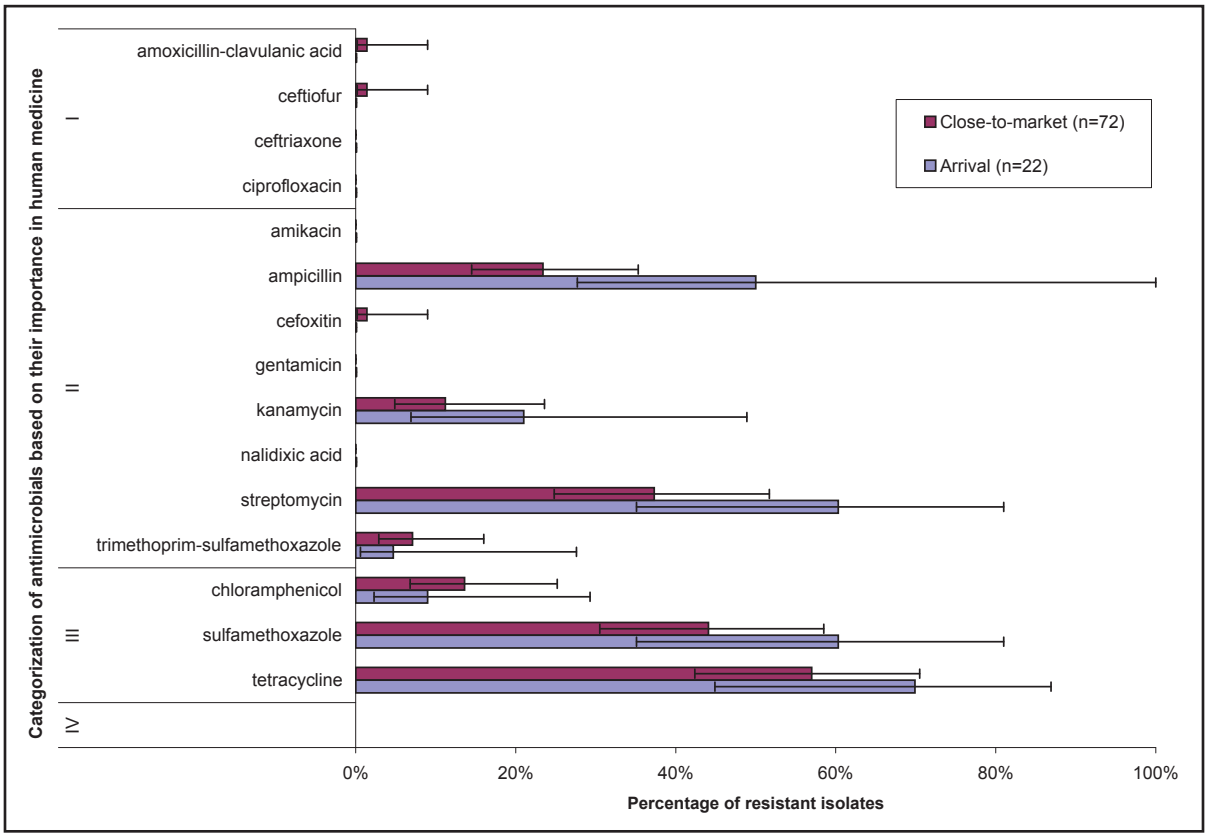


Table 16. Number of antimicrobials in resistance pattern of swine *Salmonella* isolates across serovars; *On-Farm Surveillance*, 2006.

Serovar	n (% total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Arrival cohort samples					
Typhimurium var. 5-	5 (22.7)	0	1	4	0
Typhimurium	2 (9.1)	0	1	1	0
Brandenburg	2 (9.1)	0	2	0	0
Derby	2 (9.1)	0	2	0	0
Enteritidis	2 (9.1)	1	1	0	0
Schwarzengrund	2 (9.1)	0	2	0	0
Less frequent serovars	7 (31.9)	4	3	0	0
Total	**22 (100)**	**5**	**12**	**5**	**0**
CTM regular herd and cohort samples					
Derby	16 (22.2)	3	11	2	0
Typhimurium var. 5-	11 (15.2)	2	4	5	0
London	5 (6.9)	2	3	0	0
Bovismorbificans	5 (6.9)	2	3	0	0
Typhimurium	5 (5.6)	3	0	2	0
I 4:i:-	3 (4.2)	0	3	0	0
Brandenburg	3 (4.2)	2	1	0	0
Infantis	3 (4.2)	2	1	0	0
Less frequent serovars	21 (29.2)	11	10	0	0
Total	**72 (100)**	**27**	**36**	**9**	**0**
All samples: Arrival and CTM cohort, and CTM regular herds					
Derby	18 (19.4)	3	13	2	0
Typhimurium var. 5-	16 (17.0)	2	5	9	0
Typhimurium	7 (7.4)	3	1	3	0
Bovismorbificans	5 (5.3)	2	3	0	0
Brandenburg	5 (5.3)	2	3	0	0
London	5 (5.3)	2	3	0	0
Less frequent serovars	38 (40.4)	18	20	0	0
Grand Total	**94 (100)**	**32**	**48**	**14**	**0**

Note: Serovars with less than 2% were classified as "Less frequent serovars." CTM: Close-to-market.

Swine - *Enterococcus*

(N=867)

Recovery: *Enterococcus* isolates were recovered from 81% (374/462) of swine on-farm fecal samples. Up to three isolates per samples were tested for antimicrobial resistance.

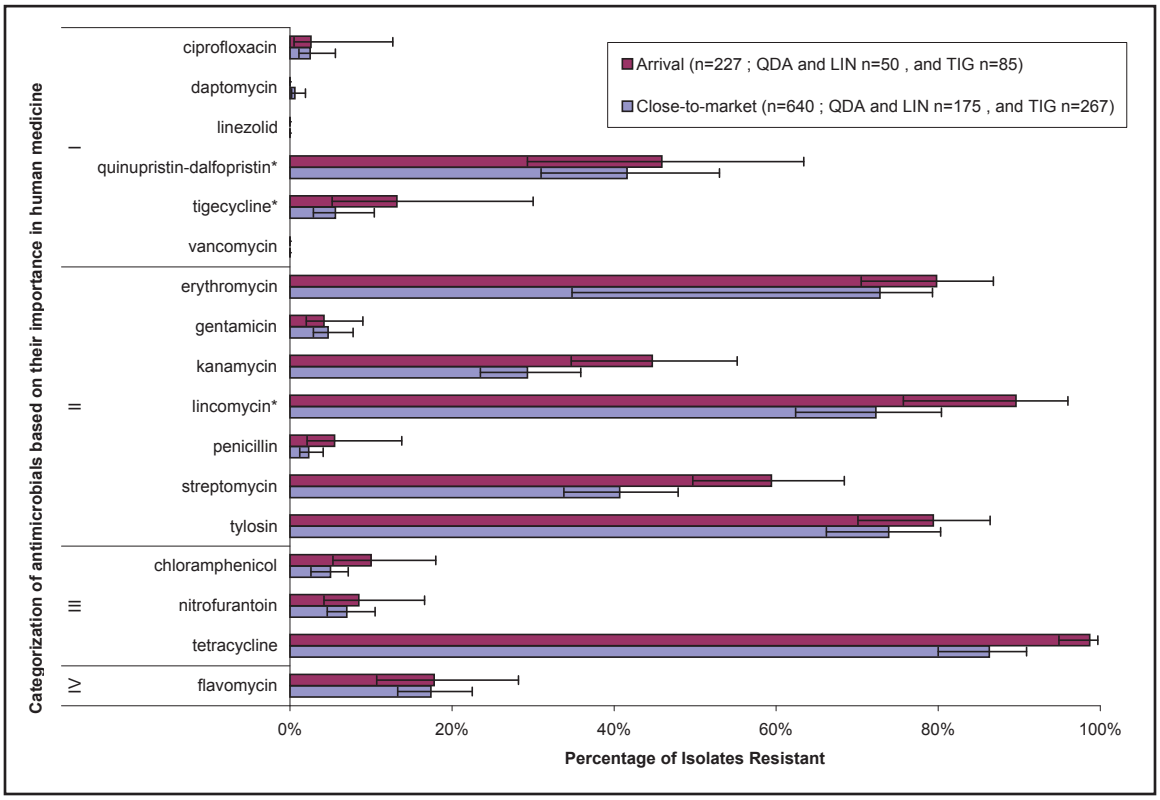
Antimicrobial Drug Resistance: See Figure 28, Table 17, and Table 57 (Appendix B.2). Resistance to one or more antimicrobials was detected in 96% (835/867) of all isolates. No close-to-market isolates were resistant to linezolid or vancomycin. No arrival isolates were non-susceptible to daptomycin or were resistant to linezolid or vancomycin. Resistance to ciprofloxacin was detected in 2% (20/867) of all isolates. Ciprofloxacin resistance was observed in *E. faecalis* (2%, 10/642), *E. faecium* (14%, 5/37), and *Enterococcus* spp. (3%, 5/188) isolates. Resistance to lincomycin was detected in 49% (18/37) of the *E. faecium* isolates and in 81% (152/188) of the *Enterococcus* spp. isolates. Resistance to quinupristin-dalfopristin was detected in 24% (9/37) of the *E. faecium* isolates and in 45% (85/188) of the *Enterococcus* spp. isolates. Resistance to tigecycline[17] was detected in 1% (3/352) of the *E. faecalis* isolates.

[17] Tigecycline was only tested on isolates from Alberta and Saskatchewan.

AMR Patterns: The most frequent patterns were resistance to ERY-TET-TYL (19%, 168/867), ERY-KAN-STR-TET-TYL (18%, 155/867) and tetracycline alone (8%, 65/867). Resistance to five or more antimicrobials was detected in 43% (369/867) of all the isolates.

In 2006, among on-farm swine *Enterococcus* isolates, no resistance was detected to vancomycin or linezolid. Resistance to tigecycline was detected in 1% (3/352) of the *E. faecalis* isolates and resistance to quinupristin-dalfopristin in 42% (94/225) of the *E. faecium* and *Enterococcus* spp. isolates.

Figure 28. Individual drug resistance in swine *Enterococcus* isolates, corrected for clustering at the herd level, including 95% confidence intervals; *On-Farm Surveillance*, 2006.



Note: Resistance to quinupristin-dalfopristin (QDA) and lincomycin (LIN) is not reported for *E. faecalis* because it is intrinsically resistant to these antimicrobials. Bacitracin tests were undertaken on all isolates except those from Alberta and Saskatchewan, but results were not presented in this figure (to see these results please consult the "On-Farm Swine 2006 Antimicrobial Resistance Supplemental Report" posted on the CIPARS website in 2009). Tigecycline was tested only on isolates from Alberta and Saskatchewan.

Table 17. Number of antimicrobials in resistance pattern in swine *Enterococcus* isolates across species; *On-Farm Swine Surveillance*, 2006.

Serovar	n (% total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Arrival cohort samples					
E. faecalis	177 (78.0)	2	84	91	0
E. faecium	5 (2.2)	0	0	4	1
Enterococcus spp.	45 (19.8)	0	12	32	1
Total	**227 (100)**	**2**	**96**	**127**	**2**
CTM cohort and regular herd samples					
E. faecalis	465 (72.7)	22	293	150	0
E. faecium	32 (5.0)	1	23	7	1
Enterococcus spp.	143 (22.3)	7	54	71	11
Total	**640 (100)**	**30**	**370**	**228**	**12**
Overall samples: Arrival and CTM cohort, and CTM regular herds					
E. faecalis	642 (74.1)	24	377	241	0
E. faecium	37 (4.3)	1	23	11	2
Enterococcus spp.	188 (21.7)	7	66	103	12
Grand Total	**867 (100)**	**32**	**466**	**355**	**14**

Note: CTM=Close-to-market.

Part IV – Surveillance of Animal Clinical Isolates

Bovine – *Salmonella*

(N=152)

Antimicrobial Drug Resistance: See Table 18 and Table 58 (Appendix B.2). Resistance to one or more antimicrobials was detected in 28% (42/152) of the isolates. No isolates were resistant to ciprofloxacin, amikacin, or nalidixic acid. No isolate had reduced susceptibility to ciprofloxacin. Seven percent (11/152) of the isolates were each resistant to amoxicillin-clavulanic acid, ceftiofur, and cefoxitin. Ten of these had intermediate susceptibility to ceftriaxone and one isolate was resistant to ceftriaxone.

AMR Patterns: The most frequent patterns were resistance to ACKSSuT (9%, 14/152) and ACKSSuT-A2C (5%, 7/152). Resistance to five or more antimicrobials was observed in 20% (30/152) of the isolates.

Serovars: See Table 18. The most frequent *Salmonella* serovars were Typhimurium, Kentucky, I 6,14,18:-:-, and Typhimurium var. 5-. Thirty-seven percent (13/35) of Typhimurium isolates were resistant to five or more antimicrobials. ACKSSuT resistance and A2C-AMP resistance were observed in 17% (6/35) and in 3% (1/35) of the Typhimurium isolates, respectively. Eighty percent (4/5) of Newport isolates were resistant to nine or more antimicrobials.

In 2006, among bovine clinical *Salmonella* isolates, resistance to amoxicillin-clavulanic acid, ceftiofur, and cefoxitin was observed in 7% (11/152) of the isolates. Resistance to ceftriaxone was observed in one isolate, while intermediate susceptibility was observed in 10 isolates.

Table 18. Number of antimicrobials in resistance pattern of bovine *Salmonella* isolates across serovars; *Surveillance of Animal Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Typhimurium	35 (23)	16	6	12	1
Kentucky	25 (16.4)	23	2	0	0
I 6,14,18:-:-	14 (9.2)	14	0	0	0
Typhimurium var. 5-	9 (5.9)	1	0	8	0
Heidelberg	7 (4.6)	3	3	1	0
Muenchen	7 (4.6)	6	0	0	1
Infantis	6 (3.9)	6	0	0	0
Thompson	6 (3.9)	6	0	0	0
Newport	5 (3.3)	1	0	0	4
Agona	4 (2.6)	2	0	0	2
Less frequent serovars	34 (22.4)	32	1	0	1
Total	**152 (100)**	**110**	**12**	**21**	**9**

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

Swine – *Salmonella*

(N=204)

Antimicrobial Drug Resistance: See Table 19 and Table 59 (Appendix B.2). Resistance to one or more antimicrobials was detected in 75% (154/204) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin, or nalidixic acid. No isolate had reduced susceptibility to ciprofloxacin. Four percent (8/204) of the isolates were resistant to amoxicillin-clavulanic acid, 3% (7/204) were resistant to ceftiofur, and 3% (6/204) had intermediate susceptibility to ceftriaxone.

AMR Patterns: The most frequent patterns observed were resistance to ACSSuT (16%, 32/204), and ACKSSuT (8%, 16/204). Resistance to ACKSSuT-SXT was found in 4% (9/204) of the isolates. Resistance to five or more antimicrobials was observed in 38% (77/204) of all isolates.
Serovars: See Table 19. The most frequent *Salmonella* serovars were Typhimurium, Typhimurium var. 5-, Derby, and Infantis. Fifty-four percent (55/102) of S. Typhimurium isolates and 42% (10/24) of Typhimurium var. 5- isolates were resistant to five or more antimicrobials. Among these, the main Typhimurium phage types were PT 104a (16/52) and PT 104 (15/52) while the main Typhimurium var. 5- phage types were 104b (5/10) and 104 (3/10). ACSSuT resistance was observed in 38% (9/24) of the Typhimurium var. 5- isolates. ACSSuT resistance and ACKSSuT resistance were observed in 23% (23/102) and in 14% (14/102) of the Typhimurium isolates, respectively.

In 2006, among swine clinical *Salmonella* isolates, 4% (8/204) were resistant to amoxicillin-clavulanic acid, 3% (7/204) were resistant to ceftiofur, and 3% (6/204) had intermediate susceptibility to ceftriaxone. The most frequent patterns were resistance to ACSSuT (16%, 32/204), and ACKSSuT (8%, 16/204). These were mainly observed in S. Typhimurium.

Table 19. Number of antimicrobials in resistance pattern of swine *Salmonella* isolates across serovars; *Surveillance of Animal Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Typhimurium	102 (50)	17	30	53	2
Typhimurium var. 5-	24 (11.8)	2	12	10	0
Derby	19 (9.3)	1	16	2	0
Infantis	9 (4.4)	7	1	1	0
I 4:i:-	6 (2.9)	3	0	3	0
Schwarzengrund	6 (2.9)	2	4	0	0
Less frequent serovars	38 (18.6)	18	14	6	0
Total	**204 (100)**	**50**	**77**	**75**	**2**

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

Chickens – *Salmonella*

(N=115)

Antimicrobial Drug Resistance: See Table 20 and Table 60 (Appendix B.2). Resistance to one or more antimicrobials was detected in 21% (24/115) of the isolates. No isolates were resistant to ceftriaxone, ciprofloxacin, amikacin gentamicin, nalidixic acid, or trimethoprim-sulfamethoxazole. No isolate had reduced susceptibility to ciprofloxacin. Five percent (6/115) of the isolates were ceftiofur resistant and 3% (3/115) had intermediate susceptibility to ceftriaxone.

AMR Patterns: The most frequent patterns were resistance to STR-TET (5%, 6/115), A2C-AMP alone (3%, 4/115), and AMP-STR-TET (3%, 3/115). Two isolates also had the A2C-AMP pattern with additional resistance to streptomycine and STR-SSS. Resistance to five ore more antimicrobials was observed in 3% (3/115) of the isolates.

Serovars: See Table 20. The most frequent *Salmonella* serovars were Enteritidis (47%, 54/115), Heidelberg (30%, 34/115), and Kentucky (7%, 8/115). This was the first time we have identified Enteritidis as the most prevalent serovar, however this serovar remained fully susceptible. Resistance to five or more antimicrobials was detected in one Typhimurium isolate and two Heidelberg isolates. All six isolates resistant to the A2C-AMP pattern were Heidelberg, the phage types were PT 41 (4/6), PT29 (1/6), and Atypical (1/6). Three of these isolates also had intermediate susceptibility to ceftriaxone. One Typhimurium was resistant to ACSSuT.

In 2006, among chicken clinical *Salmonella*, 5% (6/115) of the isolates were resistant to ceftiofur and 3% (3/115) had intermediate susceptibility to ceftriaxone. All the isolates resistant to A2C-AMP (6/6) were *S.* Heidelberg. This is the first time we have identified *S.* Enteritidis as the most prevalent serovar, however these Enteritidis isolates were all fully susceptible.

Table 20. Number of antimicrobials in resistance pattern of *Salmonella* isolates from chickens across serovars; *Surveillance of Animal Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Enteritidis	54 (47)	54	0	0	0
Heidelberg	34 (29.6)	24	8	2	0
Kentucky	8 (7)	0	8	0	0
I -:r:2	3 (2.6)	3	0	0	0
Less frequent serovars	16 (13.9)	10	5	1	0
Total	**115 (100)**	**91**	**21**	**3**	**0**

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

Turkeys – *Salmonella*

(N=49)

Antimicrobial Drug Resistance: See Table 21 and Table 61 (Appendix B.2). Resistance to one or more antimicrobials was detected in 84% (41/49) of the isolates. No isolates were resistant to ciprofloxacin, amikacin, chloramphenicol, or nalidixic acid. No isolate had reduced susceptibility to ciprofloxacin. Thirty-nine percent (19/49) of the isolates were resistant to both ceftiofur and amoxicillin-clavulanic acid. Twelve percent (6/49) of the isolates were resistant to ceftriaxone, and 20% (10/49) of isolates had intermediate susceptibility to ceftriaxone.

AMR Patterns: The most frequent patterns were resistance to tetracycline alone (18%, 9/49) and A2C-AMP-STR (14%, 7/49). Resistance to five or more antimicrobials was observed in 35% (17/49) of the isolates.

Serovars: See Table 21. The most frequent *Salmonella* serovars were Heidelberg (31%, 15/49), Hadar (18%, 9/49), and Bredeney (12%, 6/49). Resistance to five or more antimicrobials was detected in 9 Heidelberg, 6 Bredeney, 1 Brandenburg, and 1 Montevideo isolates. The AKSSuT-A2C-CRO-GEN pattern was observed in 12% (6/49) of the isolates, all of which (6/6) were Bredeney. Twenty-seven percent (13/49; 11 Heidelberg; 2 Litchfield) of the isolates had the A2C-AMP pattern.

In 2006, among clinical turkey *Salmonella*, the most frequent serovars were Heidelberg (31%, 15/49), Hadar (18%, 9/49), and Bredeney (12%, 6/49). All of the six S. Bredeney isolates had the AKSSuT-A2C-CRO-GEN pattern compared to two of the five isolates in 2005. Seventy-three percent (11/15) of the *S.* Heidelberg were resistant to A2C-AMP.

Table 21. Number of antimicrobials in resistance pattern of *Salmonella* isolates from turkeys across serovars; *Surveillance of Animal Clinical Isolates*, 2006.

Serovar	n (%total)	Number of antimicrobials in resistance pattern			
		0	1-4	5-8	9-15
		Number of isolates			
Heidelberg	15 (30.6)	2	4	9	0
Hadar	9 (18.4)	0	9	0	0
Bredeney	6 (12.2)	0	0	0	6
Saintpaul	3 (6.1)	3	0	0	0
Agona	2 (4.1)	0	2	0	0
Brandenburg	2 (4.1)	1	0	1	0
Litchfield	2 (4.1)	0	2	0	0
Montevideo	2 (4.1)	0	1	1	0
Senftenberg	2 (4.1)	0	2	0	0
Albany	1 (2)	0	1	0	0
Anatum	1 (2)	0	1	0	0
Kentucky	1 (2)	0	1	0	0
Ouakam	1 (2)	1	0	0	0
Schwarzengrund	1 (2)	1	0	0	0
Tennessee	1 (2)	0	1	0	0
Total	**49 (100)**	**8**	**24**	**11**	**6**

Section Two – Antimicrobial Use

Human Antimicrobial Use

CIPARS analysed data from the Canadian CompuScript (CCS) dataset provided by Intercontinental Medical Statistics (IMS) Health for 2000 to 2006. This dataset provides information on prescriptions dispensed by Canadian retail pharmacies. Additional information on IMS Health data collection and CIPARS analytic methodologies are described in Appendix A.5.

Canadian CompuScript – Retail Pharmacy Dispensing Data

Canada Overall

The year of 2006 was the second straight year of increases in antimicrobial prescription dispensing rates (Table 22 and Figure 29) and number of DDDs/1,000 inhabitant-days (Table 23, Figure 30, and Figure 31) since reduction started in 2001. While the increases were modest (678 prescriptions/1000 inhabitant-years in 2004, 698 in 2005, 706 in 2006) the trend is concerning. Expenditures were quite stable (Figure 29 and Table 24.

The five most frequently dispensed classes in DDDs/1,000 inhabitant-days in 2006 were: extended-spectrum penicillins (4.96); macrolides (3.79); tetracyclines (2.42); fluoroquinolones (2.16); and first generation cephalosporins (1.01) (Table 23). Antimicrobials of Very High Importance to Human Medicine (Category I) continue to represent a high proportion (16.4%) of the total DDDs dispensed during 2006 (Table 23) and increases in consumption[18] were observed in three of the seven antimicrobials included in this category: fluoroquinolones (1.83 to 2.16), combinations of penicillins, including ß-lactamase inhibitors (0.51 to 0.62), and imidazole (0.21 to 0.24). Between 2000 and 2006, first generation cephalosporins also increased from 0.75 to 1.01 DDDs/1,000 inhabitant-days, with an increase of 8.6% between 2005 and 2006. Increases in DDDs/1,000 inhabitant-days since 2000 were also observed for macrolides (3.64 to 3.79), lincosamides (0.24 to 0.36), and nitrofuran derivatives (0.42 to 0.56) (Table 23). Consumption of extended spectrum penicillins has increased since 2004, from 4.38 to 4.96 DDDs/1,000 inhabitant-days, coming close to the level of consumption observed in 2000. The consumption of most other drug classes decreased or remained stable between 2000 and 2006.

Despite the continued increase in the overall consumption of macrolides (Box 3), the consumption of erythrom ycin in DDDs/1,000 inhabitant-days continued to decrease from 0.38 in 2005 to 0.33 in 2006, while the consumption of clarithromycin increased from 2.46 in 2005 to 2.59 in 2006, representing a 5% increase (Table 23). Azithromycin consumption remained stable between 2005 and 2006.

The increased consumption of fluoroquinolones was mainly attributable to a 25% increase in consumption of moxifloxacin and 7% in ciprofloxacin (Figure 33), both of which are effective against Gram-negative organisms. During this time period, there was a decrease in the use of levofloxacin, norfloxacin, and gatifloxacin, with gatifloxacin having the largest decrease from 0.10 in 2005 to 0.02 DDDs/1000 inhabitant-days in 2006 (Figure 33).

Between 2000 and 2006, increase of use of first generation cephalosporins was observed, attributed mainly to cephalexin, which increased from 0.72 in 2000 to 0.97 DDDs/1000 inhabitant-days in 2006, representing an increase of 8% between 2005 and 2006 (Figure 34).

Provincial Variations

Differences in 2006 in the total consumption of antimicrobials (expressed in DDDs/1,000 inhabitant-days) were observed across Canada (Figure 35 and Table 67 Appendix B.4). Consumption was highest in the combined provinces of Prince Edward Island and Newfoundland, while Québec had the lowest overall antimicrobial consumption. Much of these inter-provincial variations are explained by differences in consumption of extended-spectrum penicillins, macrolides, and fluoroquinolones (Figure 35).

[18] We are computing Defined Daily Dosages (DDDs) 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, we are using the word “consumption” while recognizing the data presented slightly overestimates true consumption.

Saskatchewan has the second highest total consumption of antimicrobials, after the combined provinces of Prince Edward Island and Newfoundland. This level of consumption is driven by a higher consumption of first generation cephalosporins and tetracyclines. The higher consumption of tetracycline is due to an increase in consumption of doxycycline. Total doxycycline consumption has increased from 2.28 DDDs/1,000 inhabitant-days in 2000 to 3.32 DDDs in 2006. Among the other provinces, consumption ranged from 0.40 to 1.53 DDDs/1,000 inhabitant-days in 2006 (Figure 36).

Among the fluoroquinolone class, the combined provinces of Prince Edward Island and Newfoundland continue to increase in the total consumption of ciprofloxacin, which influenced the overall increase of consumption observed in fluoroquinolones as mentioned above. While consumption in other provinces has remained stable since 2000, consumption in these two provinces has increased from an average of 1.78 in 2000 to 3.06 DDDs/1,000 inhabitant-days in 2006 (Figure 37).

The overall increase in consumption observed in moxifloxacin was highly driven by increases in Québec and New Brunswick, which since 2005, have had similar, if not the same, total number of DDDs/1,000 inhabitant-days (Figure 38). Since the first quarter of 2001, consumption has increased from 0.1 to 0.7 DDDs/1,000 inhabitant-days in the last quarter of 2006 (Figure 38).

Comparisons with Europe

The estimation of the total amount of oral antimicrobials dispensed in 2005 by Canadian retail pharmacies was compared to the total outpatient antimicrobial use in 27 European countries[19] (Figure 39). This comparison showed that the level of consumption in Canada was similar to the level of consumption in Spain and Bulgaria. Canada's consumption represented approximately twice the level of 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). While Canada ranked 15th out of the 27 countries classified by increasing level of total antimicrobial consumption, it ranked 24th for its level of consumption of macrolides and lincosamides, and 21st for its level of consumption of quinolones (largely composed of fluoroquinolones), a position similar to 2004 when Canada ranked 14th out of 25 countries (CIPARS, 2005)

Comparisons with Pharmanet

Comparisons with Pharmanet indicated that in British Columbia IMS data overestimated total consumption by roughly 12%, mainly due to purchases made by non-BC residents (CIPARS, 2005). If the people identified as non-BC residents in this comparison were also not Canadian residents, and we reduced the total consumption in Canada by 12%, then Canada would rank 19th out of the 27 countries, between Slovania and the United Kingdom.

The year of 2006 was the second straight year of increases in antimicrobial prescription dispensing rates and number of DDDs/1,000 inhabitant-days since reduction started in 2001. Consumption was highest in the combined provinces of Prince Edward Island and Newfoundland, while Québec had the lowest overall antimicrobial consumption. Among the fluoroquinolone class, the combined provinces of Prince Edward Island and Newfoundland continue to increase in the total consumption of ciprofloxacin, while consumption in other provinces has remained stable since 2000.

[19] ESAC, 2007. http://www.esac.ua.ac.be/main.aspx?c=*ESAC2&n=21600.

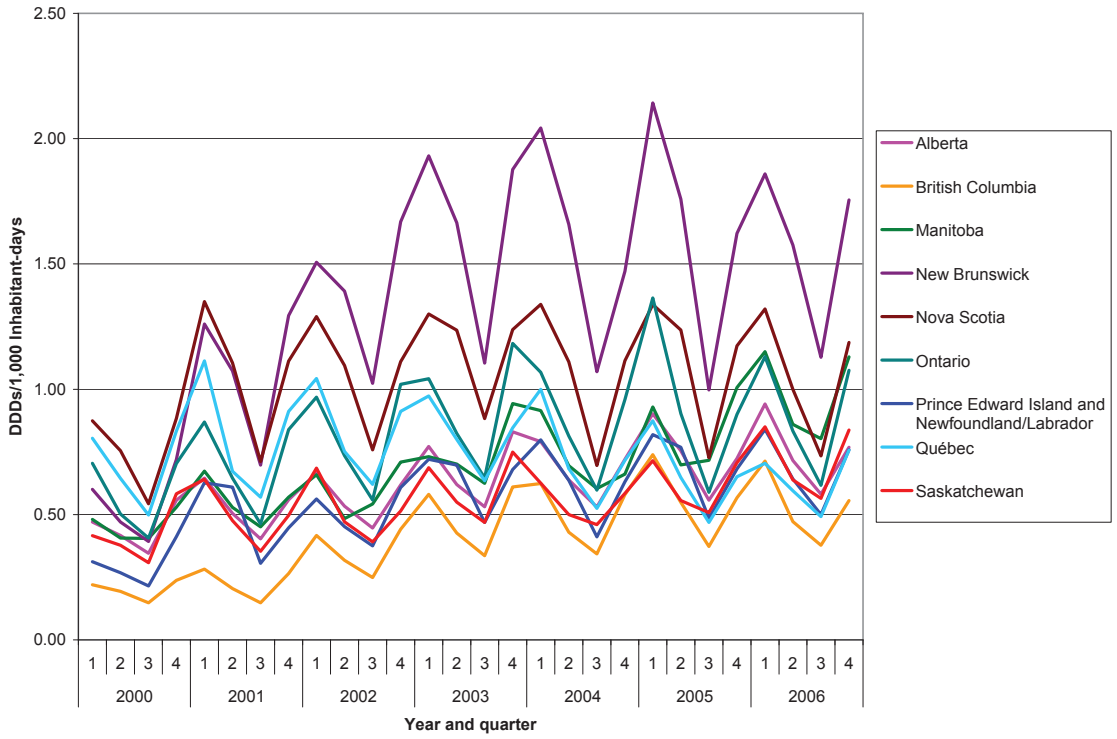
Box 3. Macrolide consumption and resistance in Canada.

Macrolides are commonly used as empirical therapy for patients with suspected pneumococcal infections and are the second most prescribed class of antimicrobials[1]. To prevent macrolide treatment failures, guidelines recommend that people who have been exposed to macrolides in the previous three months should not be prescribed any macrolides[1].

In the L. Dumont Regional Hospital in Moncton, New Brunswick, physicians have been observing an increase in the number of treatment failure among immunocompromised adults and children with streptococcal pharyngitis[2]. To evaluate the current resistance rates among group *A Streptococcus*, physicians tested throat swabs collected during the month of December 2006. Results showed that 40% and 43% of the isolates were resistant to clindamycin and erythromycin, respectively. To investigate if a relationship between the use of macrolides and resistance existed, macrolide consumption data for this province was evaluated. CIPARS analysis revealed that the rate of prescription of azithromycin in this province is two-to-three times that of the Canadian mean (Figure A).

In a letter that the physicians from this hospital wrote to the Canadian Medical Association Journal (CMAJ 2007; 177 (2): p.177), they recommend that "antibiotics should be prescribed only to treat obvious bacterial infections and only when an antigen-detection test or a culture or both are positive; and that macrolides are considered to be a third-line therapy for streptococcal pharyngitis and their use should be limited accordingly".

Figure A. Provincial consumption of oral azithromycin from 2000 to 2006[3].



[1] Daneman N, McGeer A, Green K, Low DE. Macrolide Resistance in Bacteremic Pneumococcal Disease: Implications for Patient Management. Clinical Infectious Diseases 2006; 43: 432-8.

[2] Lavergne V, Thibault L, and Garceau R. Macrolide Resistance in Streptococcal Pharyngitis. Can Med Assoc J 2007; 177: 177.

[3] Government of Canada. Canadian Provincial Consumption of Oral Macolides in the Community from 2000-2006, Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS). Guelph, ON: Public Health Agency of Canada, 2007.

Table 22. Total number of prescriptions of oral antimicrobials per 1,000 inhabitants dispensed in Canada; 2000-2006.

	ATC Class		Number of prescriptions/1,000 inhabitants						
			2000	2001	2002	2003	2004	2005	2006
I	J01CR	Combinations of penicillins, incl. ß-lactamase inhibitors	18.66	18.41	17.54	17.69	16.98	18.10	18.77
	J01DD	Third-generation cephalosporins	5.66	5.28	4.83	4.23	3.68	3.70	3.81
	J01MA	Fluoroquinolones	76.23	81.03	85.73	91.74	94.22	96.87	99.65
	J01XA	Glycopeptides	0.14	0.14	0.16	0.19	0.34	0.40	0.38
	J01XD	Imidazole	NA	16.65	16.71	17.09	17.25	16.98	18.19
	J01XX08	Linezolid	NA	<0.01	0.01	0.02	0.04	0.05	0.05
II	J01CA	Penicillins with extended spectrum	193.18	183.54	171.05	169.81	156.08	165.08	165.63
	J01CE	ß-lactamase sensitive penicillins	45.42	42.10	39.85	39.62	36.59	36.14	36.75
	J01CF	ß-lactamase resistant penicillins	19.78	18.38	16.78	15.61	14.17	12.86	12.25
	J01DB	First-generation cephalosporins	41.03	41.70	43.07	45.23	45.65	48.11	51.38
	J01DC	Second-generation cephalosporins	55.09	48.95	43.06	41.41	39.37	38.97	36.31
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	56.52	50.62	44.56	41.05	37.12	35.45	35.73
	J01FA	Macrolides	146.55	149.72	145.48	149.00	138.51	146.91	144.00
	J01FF	Lincosamides	15.92	16.74	17.63	18.48	18.85	19.28	21.37
	J01GB	Aminoglycosides	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	0.08	0.06	0.05	0.04	0.05	0.01	<0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	3.50	2.43	1.58	1.05	0.67	0.52	0.49
	J01XC	Steroid antibacterials	0.06	0.06	0.05	0.05	0.05	0.06	0.06
III	J01AA	Tetracyclines	43.47	41.16	39.31	38.41	36.71	35.74	36.56
	J01BA	Amphenicols	<0.01	<0.01	<0.01	NA	<0.01	<0.01	NA
	J01EB	Short-acting sulfonamides	0.07	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01EC	Intermediate-acting sulfonamides	0.02	<0.01	<0.01	0.01	0.01	0.01	<0.01
	J01XE	Nitrofuran derivatives	14.61	15.76	16.41	17.48	19.13	20.02	22.09
	J01XX	Fosfomycin	0.44	0.47	0.29	0.21	0.14	0.11	0.09
NC	J01EA	Trimethoprim and derivatives	2.22	2.12	2.13	2.16	2.02	1.92	2.05
	J01XX05	Methenamine	0.27	0.28	0.29	0.28	0.25	0.25	0.25
	J01	**Total**	**738.98**	**735.62**	**706.57**	**710.89**	**677.86**	**697.54**	**705.87**

Note: Roman numerals I-III indicate the categorization of antimicrobials based on their importance in human medicine as outlined by the Veterinary Drugs Directorate. NC: Not classified. NA: Not available.

Figure 29. Total number of prescriptions and total cost per 1,000 inhabitants-of oral antimicrobials in Canada, 2000-2006.

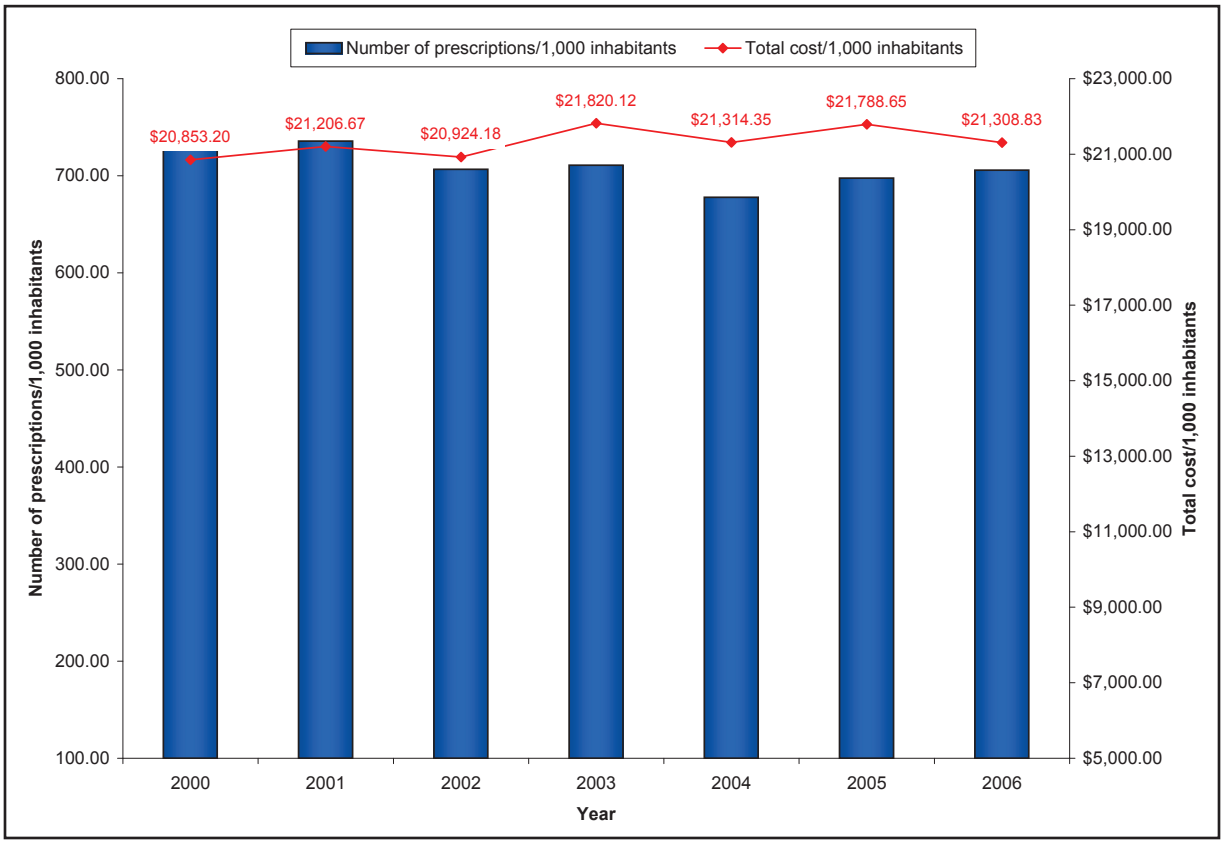


Table 23. Defined daily doses of oral antimicrobials by ATC class in Canada (DDDs/1,000 inhabitant-days); 2000-2006.

	ATC Class		DDDs/1,000 inhabitant-days						
			2000	2001	2002	2003	2004	2005	2006
	J01CR	Combinations of penicillins, incl. ß-lactamase inhibitors	0.51	0.52	0.50	0.52	0.52	0.58	0.62
	J01DD	Third-generation cephalosporins	0.10	0.09	0.08	0.07	0.06	0.06	0.06
I	J01MA	Fluoroquinolones	1.83	1.93	1.99	2.08	2.09	2.13	2.16
	J01XA	Glycopeptides	<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
	J01XX08	Linezolid	NA	<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	4.70	4.96
	J01CE	ß-lactamase sensitive penicillins	0.67	0.63	0.60	0.60	0.55	0.55	0.56
	J01CF	ß-lactamase resistant penicillins	0.37	0.35	0.32	0.31	0.28	0.26	0.25
	J01DB	First-generation cephalosporins	0.75	0.77	0.80	0.85	0.87	0.93	1.01
	J01DC	Second-generation cephalosporins	1.39	1.22	1.05	1.00	0.94	0.95	0.90
II	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	1.39	1.25	1.12	1.04	0.92	0.87	0.87
	J01FA	Macrolides	3.64	3.62	3.42	3.57	3.43	3.74	3.79
	J01FF	Lincosamides	0.24	0.27	0.28	0.31	0.32	0.33	0.36
	J01GB	Aminoglycosides	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	J01RA	Sulfonamide combinations (excl. trimethoprim)	0.03	0.02	0.01	0.01	0.01	<0.01	<0.01
	J01XC	Steroid antibacterials	<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	2.35	2.42
	J01BA	Amphenicols	<0.01	<0.01	<0.01	NA	<0.01	<0.01	NA
III	J01EB	Short-acting sulfonamides	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
	J01XE	Nitrofuran derivatives	0.42	0.44	0.45	0.47	0.49	0.52	0.56
	J01XX	Fosfomycin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NC	J01EA	Trimethoprim and derivatives	0.07	0.07	0.07	0.07	0.06	0.06	0.06
	J01XX05	Methenamine	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	J01	**Total antibacterial drugs**	**19.23**	**18.93**	**18.11**	**18.21**	**17.58**	**18.27**	**18.84**

Note: Roman numerals I-III indicate the categorization of antimicrobials based on their importance in human medicine as outlined by the Veterinary Drugs Directorate. NC: Not classified. NA: Not available.

Figure 30. Percentage of oral antimicrobials dispensed in Canada (DDDs/1,000 inhabitant-days); 2006.

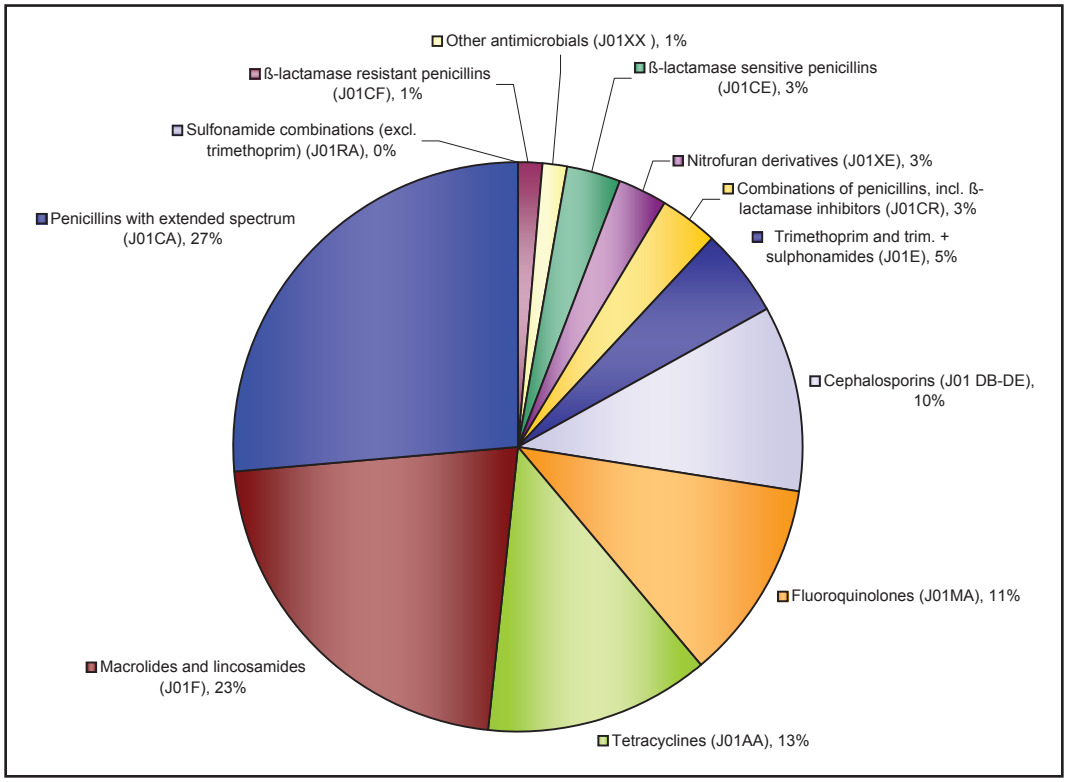


Figure 31. Temporal variations of the percentage of DDDs/1,000 inhabitant-days for each class of oral antimicrobials dispensed in Canada; 2000-2006.

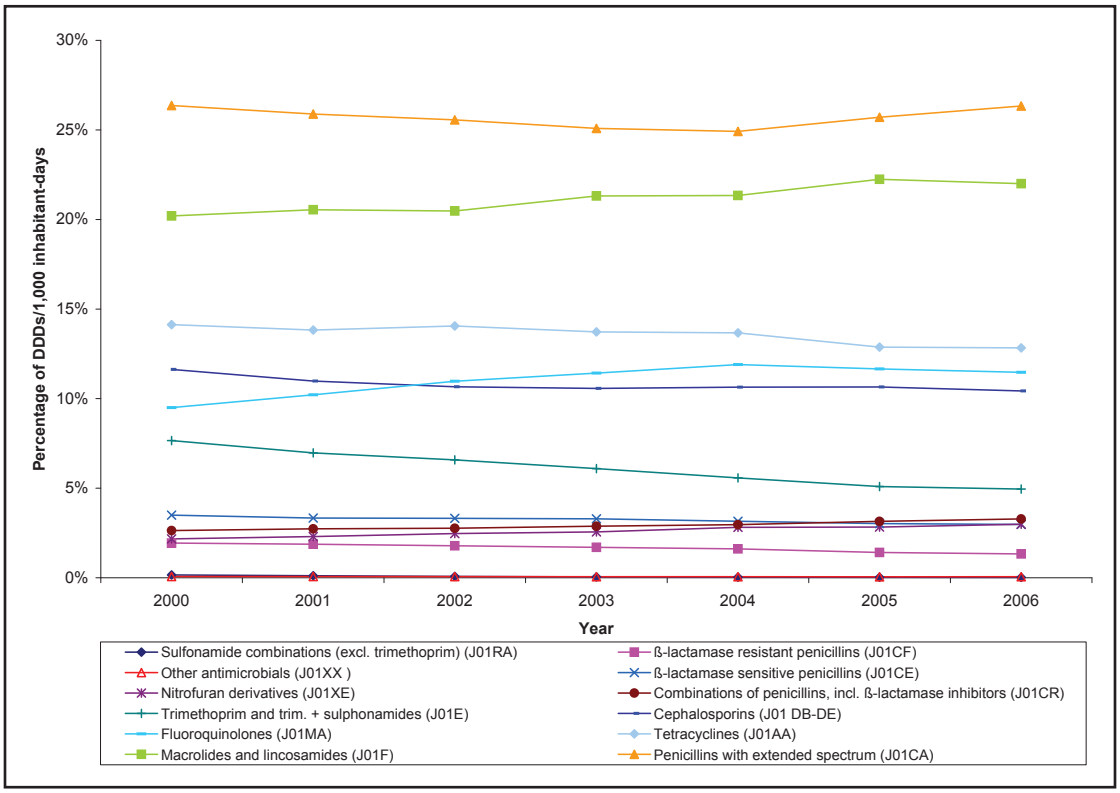


Table 24. Total cost of oral antimicrobials dispensed in Canada (Total cost $/1,000 inhabitants); 2000-2006.

	ATC Class		Total cost/1,000 Inhabitants ($)						
			2000	2001	2002	2003	2004	2005	2006
I	J01CR	Combinations of penicillins, incl. beta-lactamase inhibitors	758.68	741.82	644.84	632.84	584.65	620.73	648.91
	J01DD	Third-generation cephalosporins	212.26	196.78	179.57	155.33	133.22	137.55	137.91
	J01MA	Fluoroquinolones	4,285.71	4,555.96	4,758.29	5,078.69	4,859.20	4,372.80	4,235.80
	J01XA	Glycopeptides	51.03	54.88	62.08	76.38	131.23	152.36	144.51
	J01XD	Imidazole	NA	198.89	224.55	243.26	261.21	264.19	291.99
	J01XX08	Linezolid	NA	6.36	19.53	43.61	71.59	109.63	108.93
II	J01CA	Penicillins with extended spectrum	2,662.57	2,559.11	2,416.25	2,456.31	2,295.16	2,450.82	2,451.91
	J01CE	Beta-lactamase sensitive penicillins	497.32	467.30	452.74	463.27	435.95	435.04	440.60
	J01CF	Beta-lactamase resistant penicillins	287.70	272.68	251.58	242.19	226.14	206.66	197.27
	J01DB	First-generation cephalosporins	736.71	756.44	798.94	863.21	890.36	944.92	1,010.50
	J01DC	Second-generation cephalosporins	2,335.89	2,134.36	1,820.11	1,807.37	1,797.76	1,831.96	1,767.25
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	632.11	571.05	511.01	481.11	438.79	419.68	421.87
	J01FA	Macrolides	5,800.28	6,177.44	6,219.24	6,639.65	6,521.81	7,186.97	6,643.23
	J01FF	Lincosamides	666.80	605.60	635.04	654.75	675.26	691.02	760.54
	J01GB	Aminoglycosides	0.93	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
	J01MB	Other quinolones	3.62	3.01	2.53	2.27	2.16	0.45	0.04
	J01RA	Sulfonamide combinations (excl. trimethoprim)	95.14	66.22	43.47	29.38	19.60	16.02	15.07
	J01XC	Steroid antibacterials	6.14	6.74	6.04	6.30	6.24	7.57	7.03
III	J01AA	Tetracyclines	1,456.11	1,451.83	1,485.89	1,524.95	1,512.46	1,468.37	1,506.24
	J01BA	Amphenicols	0.02	0.05	0.01	NA	<0.01	<0.01	NA
	J01EB	Short-acting sulfonamides	2.79	0.35	0.03	0.02	0.02	0.01	0.01
	J01EC	Intermediate-acting sulfonamides	0.45	0.40	0.32	0.48	0.22	0.45	0.47
	J01XE	Nitrofuran derivatives	290.94	312.33	332.83	364.93	404.48	428.08	475.85
	J01XX	Fosfomycin	14.71	16.06	10.39	7.60	5.52	4.61	3.38
NC	J01EA	Trimethoprim and derivatives	47.67	43.68	41.75	39.62	35.03	32.87	33.31
	J01XX05	Methenamine	7.64	7.27	7.14	6.59	6.31	5.89	6.21
	J01	**Total**	**20,853.20**	**21,206.67**	**20,924.18**	**21,820.12**	**21,314.35**	**21,788.65**	**21,308.83**

Note: Roman numerals I-III indicate the categorization of antimicrobials based on their importance in human medicine as outlined by the Veterinary Drugs Directorate. NC: Not classified. NA: Not available.

Figure 32. Oral macrolides dispensed in Canada (DDD/1,000 inhabitant-days); 2000-2006.

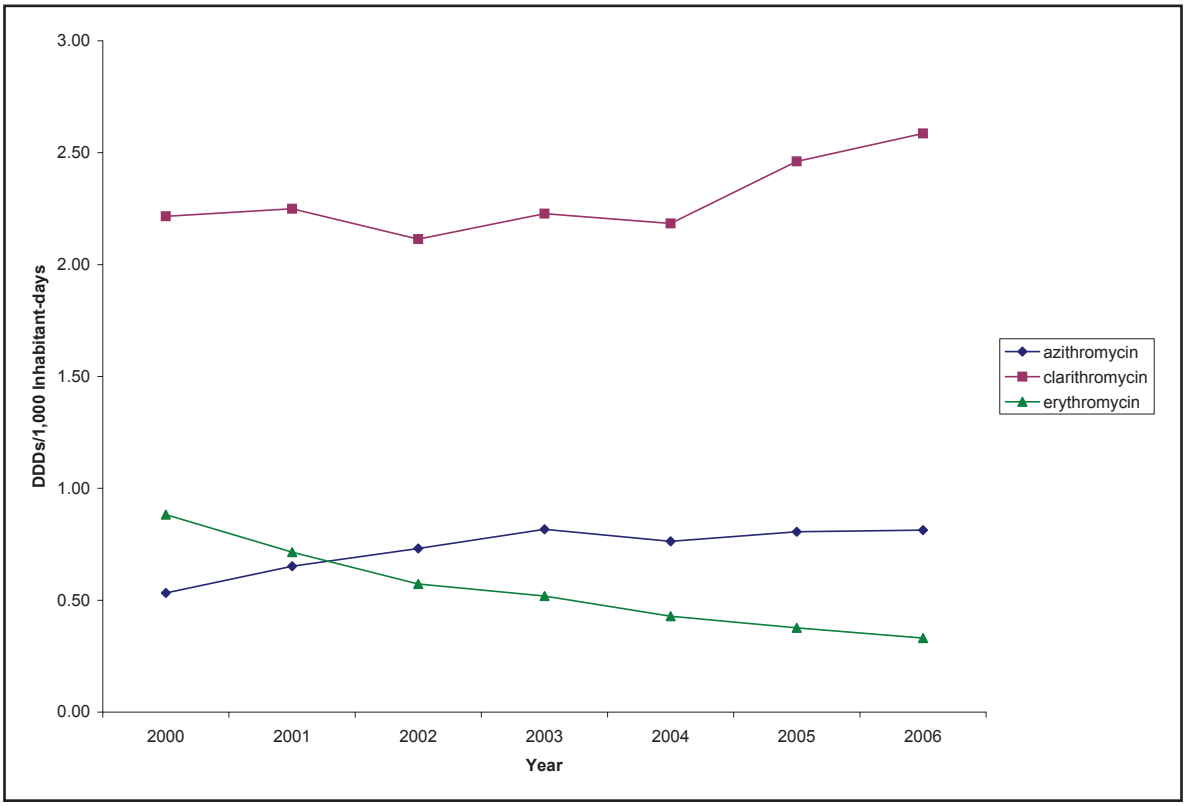


Figure 33. Oral fluoroquinolones dispensed in Canada (DDD/1,000 inhabitant-days); 2000-2006.

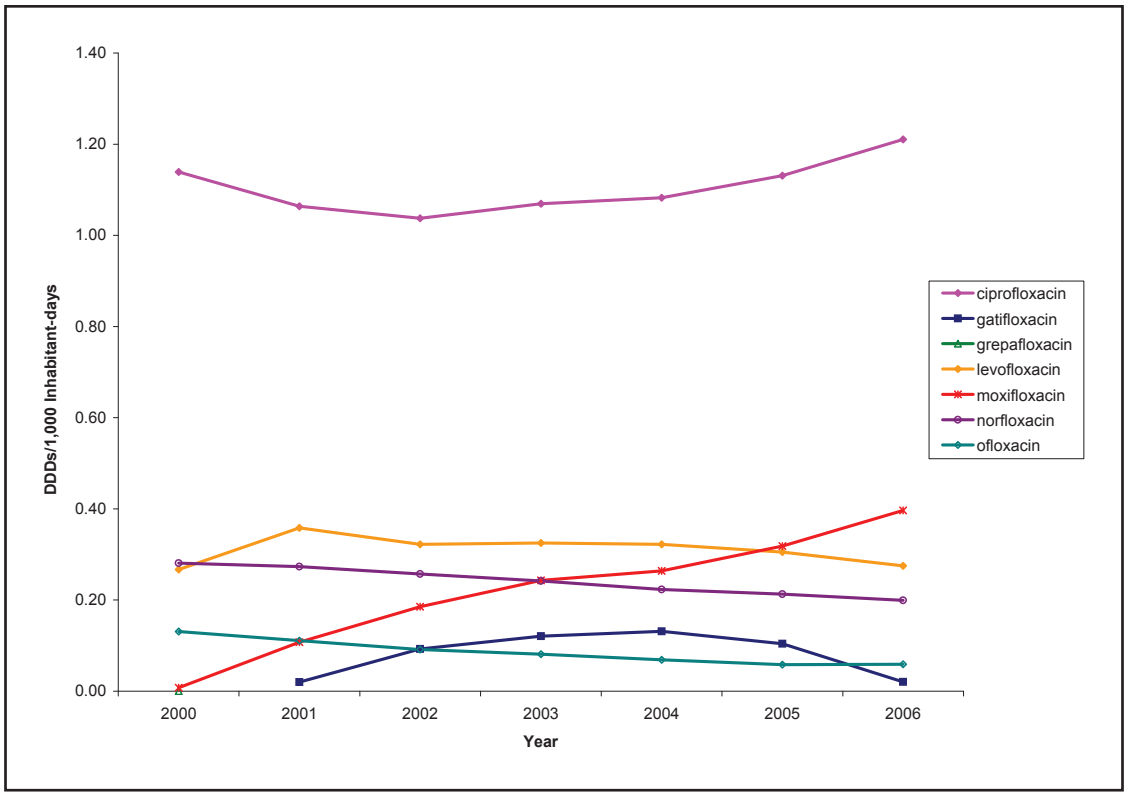


Figure 34. Oral first generation cephalosporins dispensed in Canada (DDD/1,000 inhabitant-days); 2000-2006.

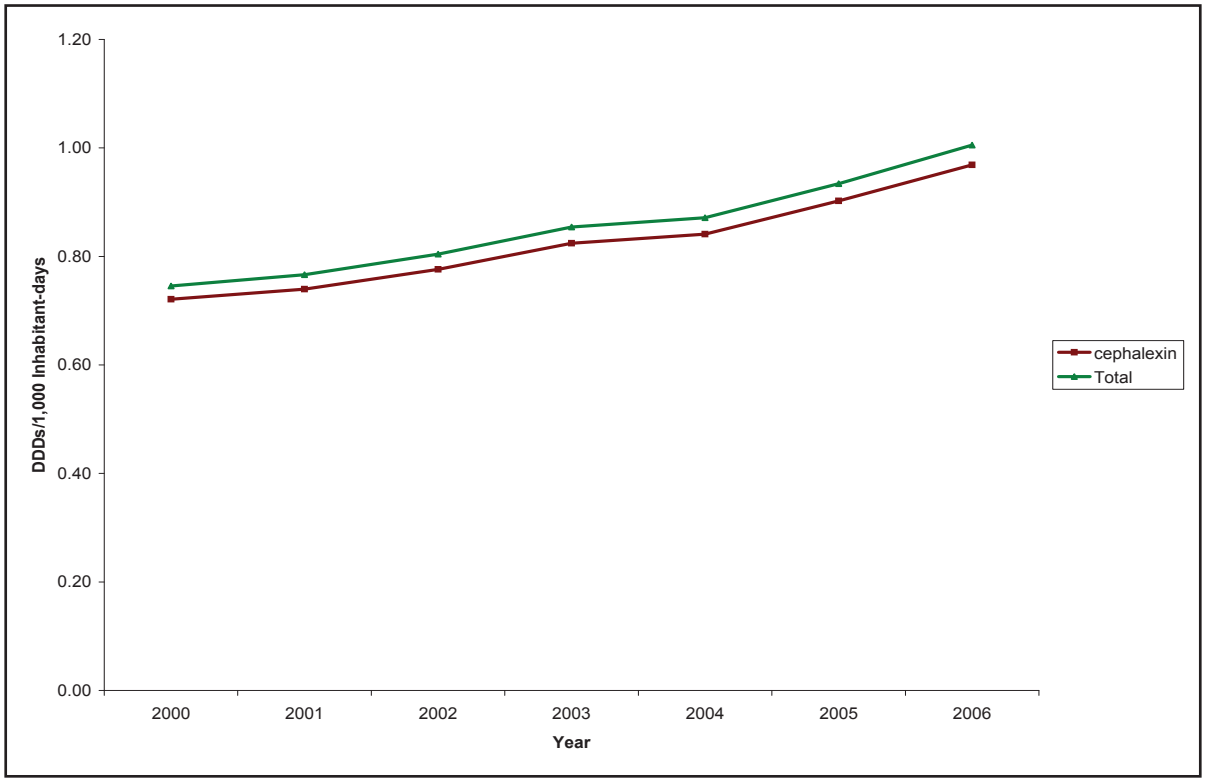


Figure 35. Antimicrobial consumption by province in Canada (DDD/1,000 inhabitant-days); 2006.

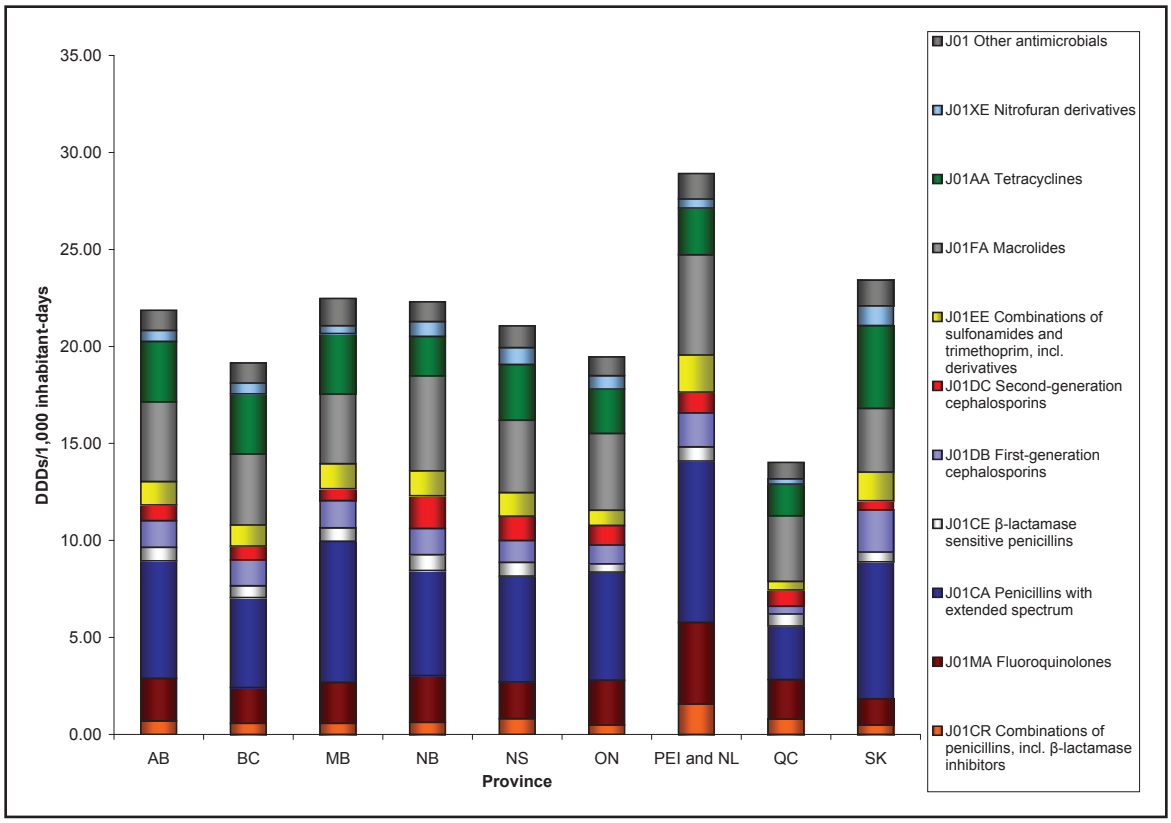


Figure 36. Oral doxycycline dispensed by province (DDD/1,000 inhabitant-days); 2000-2006.

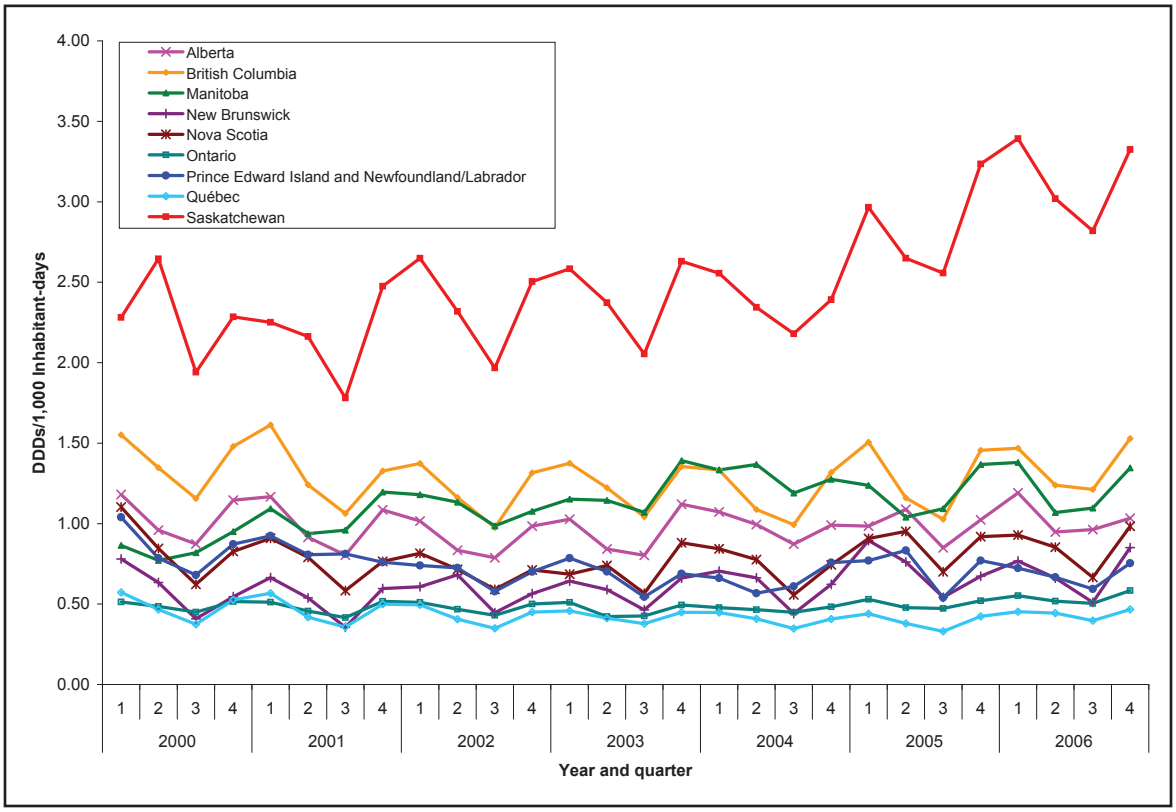


Figure 37. Oral ciprofloxacin dispensed in Canada (DDD/1,000 inhabitant-days); 2000-2006.

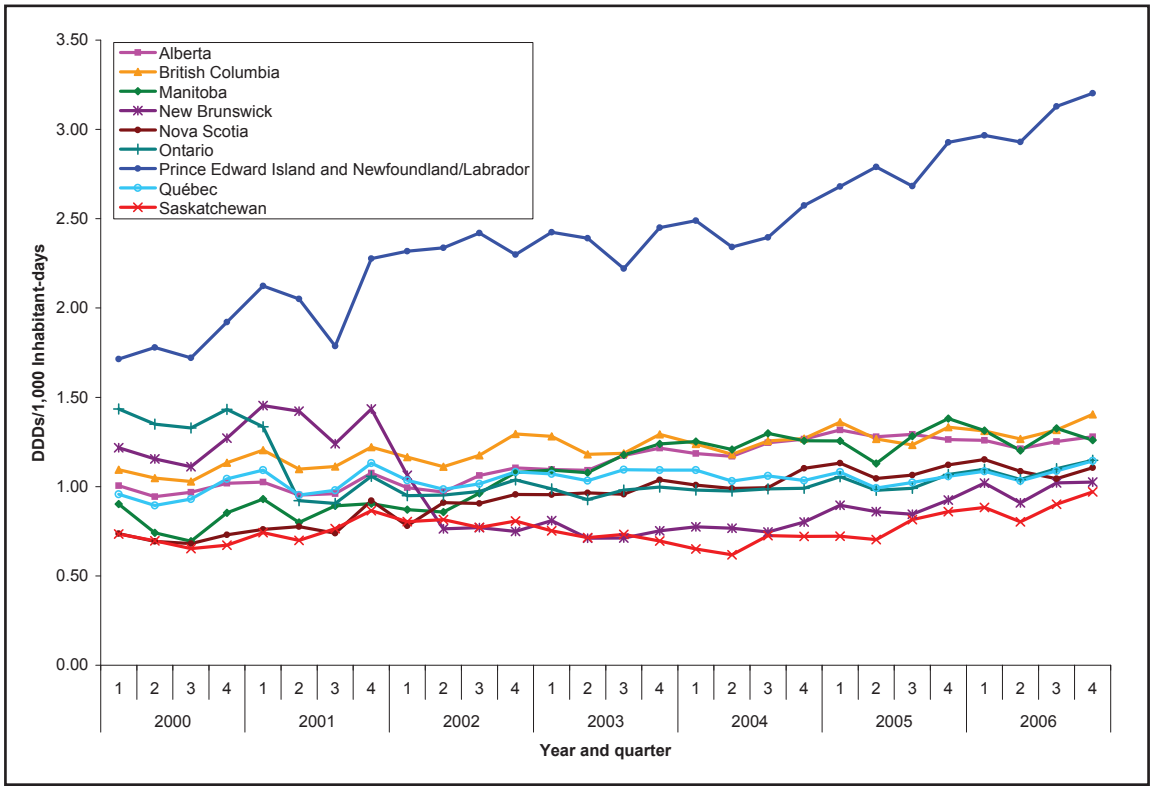


Figure 38. Oral moxifloxacin dispensed in Canada (DDD/1,000 inhabitant-days); 2000-2006.

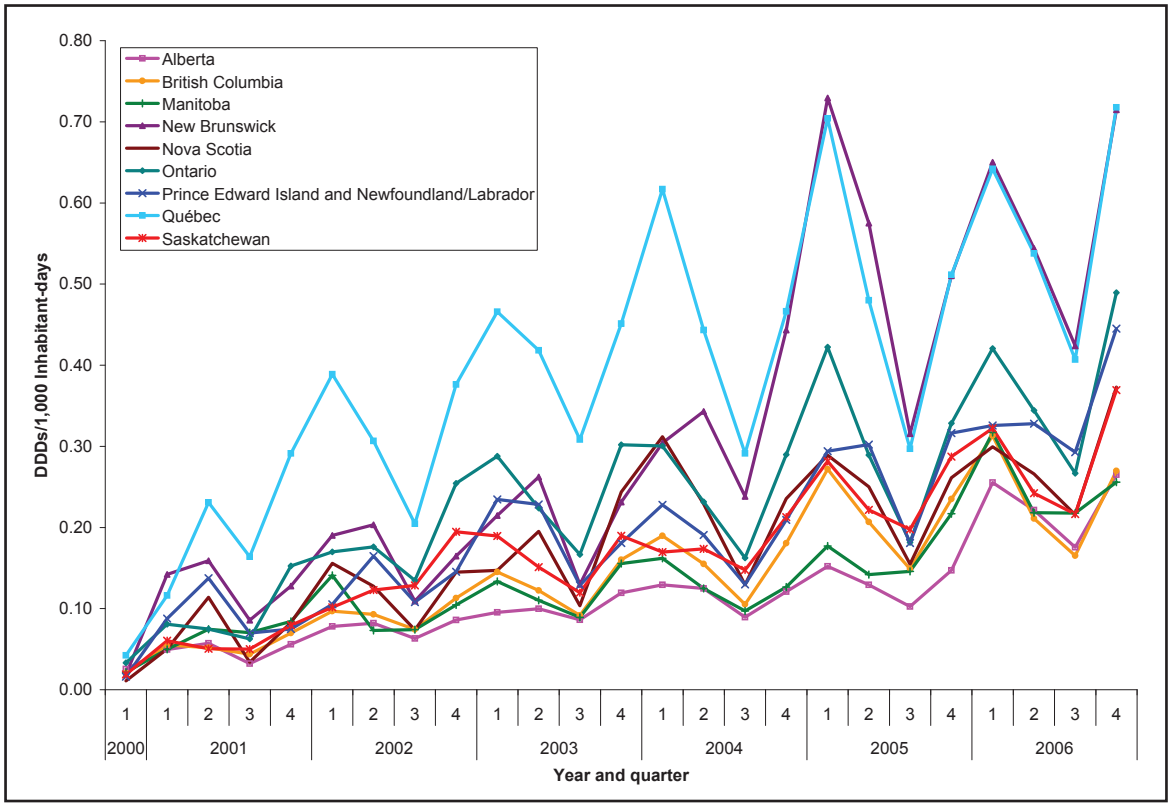
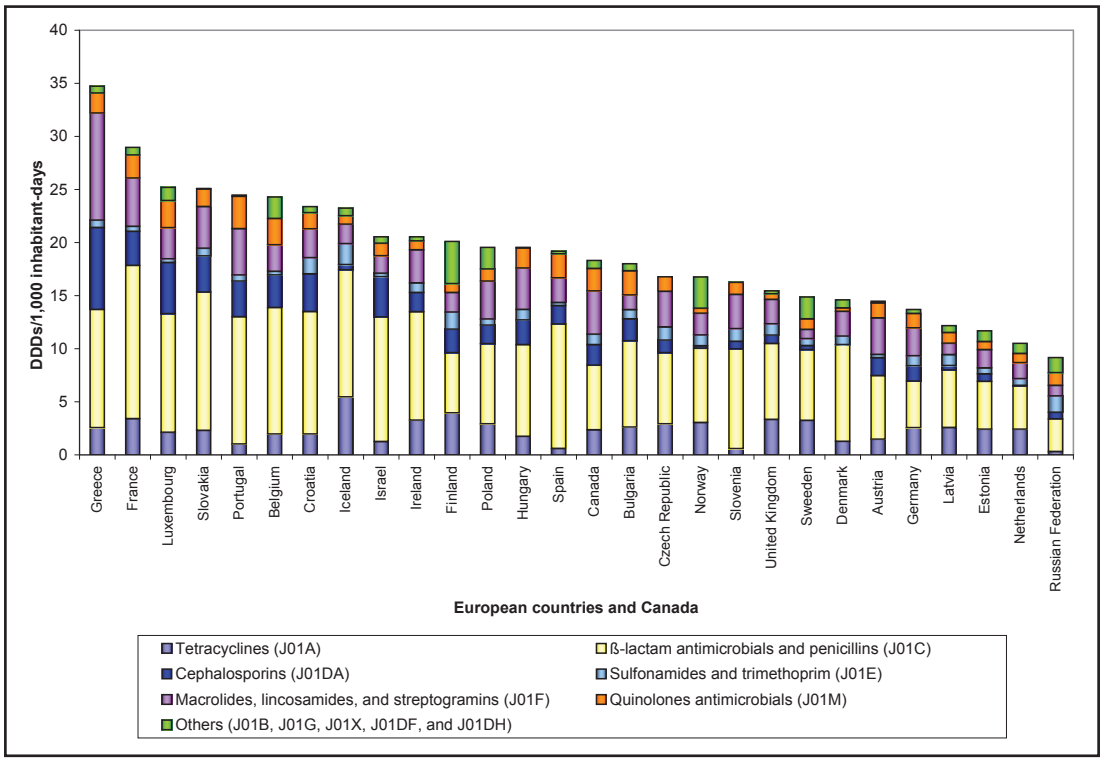


Figure 39. Antimicrobial consumption in 27 European countries and in Canada (DDD/1,000 inhabitant-days); *ESAC and CIPARS*, 2006.



Antimicrobial Use in Animals

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 PHAC have investigated several sources and means of acquiring reliable and valid data on antimicrobial use in food-animals in Canada. At the federal level there is no current legislative mechanism to acquire this data. Over-the-counter (OTC) antimicrobial sales (including in-feed use) and the practice of veterinary medicine are regulated by each province. Industry level data were provided for 2001-2003 from a program operated by the Canadian Animal Health Institute (CAHI), but the program was temporarily suspended and the data withdrawn. CAHI cited logistical and methodological issues. New data collected through a revised program have been provided by CAHI to PHAC for 2006 (Table 25); 2007 data will be posted on the CIPARS website in the near future.

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

The *On-Farm Surveillance* component of CIPARS was initiated in 2003 with five-year funding from Agriculture and Agri-Food Canada's Agriculture Policy Framework. Data collection is ongoing in the swine industry to test the feasibility, and sustainability of an ongoing farm-level surveillance program. Antimicrobial use data from this initiative were not available for inclusion in this report; they will be published in a future report once analysis is completed.

Please check the CIPARS website for updates on data from CAHI, publication of antimicrobial use research, and CIPARS On-farm use data.

Kilograms of Antimicrobials in Dosage Form Distributed in Canada for Use in Animals in 2006

CAHI[20] is the trade association representing the companies that manufacture and distribute drugs for administration to companion, sporting, and food-animals in Canada. It is estimated by CAHI that CAHI member sales represent over 95% of licensed animal pharmaceutical product sales in Canada. CAHI collected data from its members and one non-member on the total kilograms of antimicrobials distributed by firms in 2006. The data were collected electronically, by individual product and aggregated by active ingredient. The data collection and analysis was conducted by a third party, Impact Vet[21]. The data were provided to PHAC by CAHI, aggregated to the class level (Table 25). All licensed antimicrobials for use in food, sporting and companion animals and fish were included. These data do not specifically represent antimicrobial use in a given year; but rather reflect the volume of antimicrobial distributed by manufacturers. The distribution data should approximately correspond to the amounts used, especially over several years of data, but on a yearly basis may vary from actual use due to the time lag between distribution and actual use, as well as stockpiling at various points in the distribution system.

The data do not include antimicrobial products imported under the federal *Food and Drugs Act & Regulations* personal use provision (own use imported, OUI), or active pharmaceutical ingredients (API) (drugs imported in non-dosage form and compounded by a licensed pharmacist and/or veterinarian) used in veterinary medicine and food-animal production. The federal *Food and Drug Regulations* prohibit the importation of unapproved veterinary drugs intended for sale in Canada. OUI and API drugs are imported and used under the existing regulatory framework, and are not subject to pre- or post-marketing assessment by Health Canada. The Own Use Importation policy, which is specifically intended to allow the importation of drugs for human use, does not prohibit the importation of veterinary drugs for use in animals owned by the importer. The amounts of API antimicrobial and OUI unapproved veterinary drugs imported into Canada are unknown. The 2007 International Federation for Animal Health Report[22] estimated the opportunity value[23] for OUI pharmaceutical use for all drugs, including antimicrobials, in animals in Canada at CDN$100,000,000. Based on this, CAHI has estimated that OUI and API drug use is 30-40% of the value of the licensed animal pharmaceuticals marketed nationally; however, CIPARS has no mechanism by which to validate this estimate. The Veterinary Drugs Directorate, in consultation with Health Canada's multi-stakeholder Task Force

[20] cahi-icsa.com.

[21] Division of AgLine TI Ltd., impactvet.com.

[22] Benchmarking the Competitiveness of the Canadian Animal Health Industry Report, International Federation for Animal Health, 2007.

[23] Opportunity value: The estimated value of non-approved drugs equated to the dollar value of comparable approved products.

on Personal Use Importation, is exploring options to address the OUI issue. Health Canada is also working on the development of a regulatory framework based on the implementation of the Good Manufacturing Practices (GMPs) Guide for APIs (ICH Q7A Guideline) to include APIs destined for veterinary use.

The CAHI data on distribution of antimicrobials for use in animals provide a context in which to interpret animal antimicrobial use data generated through research and on-farm data collection, and will provide a means to monitor gross changes over time of antimicrobial use in animals.

Table 25. Kilograms of antimicrobials in dosage form distributed in Canada for use in animals; *Canadian Animal Health Institute*, 2006.

Antimicrobial Class	2006 Kg of active ingredient
Ionophore/chemical coccidiostat and Arsenicals	455,753
Tetracyclines	847,281
ß-Lactams	58,538
Cephalosporins	702
Macrolides/pleuromutilins	136,497
Lincosamides	67,825
Aminoglycosides	5,122
Fluoroquinolones	591
Trimethoprims/sulphonamides	50,789
Other	143,029
Total	**1,766,126**

Section Three – Integrated Surveillance

Extended Spectrum Cephalosporin Resistance in Humans and Animals: A Public Health Concern

Background and Rationale for Concern

- *Salmonella* Heidelberg is among the top three serovars responsible for human cases of salmonellosis in North America (Demczuk et al., 2005). It can cause severe, invasive infections in humans and accounts for the largest proportion of the non-typhoidal human isolates from extra-intestinal sites such as blood and urine (a potential marker for invasiveness). It is also a common serovar among *Salmonella* isolated from abattoir, retail, and clinical samples from chickens (CIPARS, 2002 to 2005)[24].

- The resistance profile of *S.* Heidelberg often includes resistance to ceftiofur and intermediate susceptibility to ceftriaxone[21]. Intermediate susceptibility to ceftriaxone might indicate limited treatment options for specific sub-populations of patients such as pregnant women and children who develop extra-intestinal salmonellosis (Shea *et al.*, 2004), or patients with fluoroquinolone-resistant strains of *Salmonella*.

- Bacterial resistance to ß-lactams (such as penicillins and cephalosporins, including ceftiofur) has been increasingly observed in gram-negative bacteria of human and animal origin (Li et *al.*, 2007). Of particular concern is the acquired resistance to extended spectrum cephalosporins associated with plasmid-encoded ß-lactamases such as the *AmpC*-type CMY enzymes and the CTX-M extended-spectrum ß-lactamases (ESBLs). They often coexist with other genetic elements of resistance leading to multidrug resistance (Li et *al.*, 2007). Plasmid-encoded ß-lactamases such as CMY enzymes and the ESBLs (e.g. CTX-M, TEM, and SHV enzymes) are reported in bacteria recovered from human samples (Stürenburg, 2003).

- Ceftiofur is an extended spectrum cephalosporin currently approved only for veterinary use in Canada. It is licensed for many animal species including cattle, swine, horses, sheep, turkeys, dogs, and cats, but ceftiofur is not licensed for use in chickens. Anecdotal information suggests that it is used in an extra-label[25] manner in chickens and in various other animal species.

- Similar concerns have been raised in the United States. In June 2008, the US Food and Drug Administration (FDA) issued an order prohibiting the extra-label use of cephalosporins in all food-producing animals, which includes in ovo use in chicken eggs. This action was taken because of concerns that the extra-label use would lead to the emergence of cephalosporin-resistant strains of foodborne bacterial pathogens and present a risk to public health.

- Previous CIPARS reports[21] (2003-2005) highlighted a temporal correlation between changing levels of ceftiofur-resistant *S.* Heidelberg strains and *E. coli* from retail chicken and humans.

- Many other *Salmonella* serovars as well as *E. coli* from different agri-food sources were ceftiofur-resistant. Ceftiofur resistance in generic *E. coli* is concerning since there is an abundance of generic *E.coli* common to many animal species and if these harbour ceftiofur resistance, then this forms a reservoir of genetic elements of cephalosporin resistance which could be transferred to more pathogenic human bacteria.

Surveillance Findings

- From 2002 to 2006, CIPARS surveillance indicated that ceftiofur resistance has been observed in *E. coli* and in 55 *Salmonella* serovars recovered from animal samples (abattoir, retail, and clinical) and human clinical samples (Table 26).

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[24] http://www.phac-aspc.gc.ca/cipars-picra/index_e.html.

[25] Extra-label involves use other than what is on the label such as use for a different species, different age class, different indication, or at a different dose/duration. It should be noted that extra-label use of drugs in food-producing animals is not recommended by the Veterinary Drug Directorate and any such use is considered unapproved. The practice of veterinary medicine falls under provincial government mandate. Under provincial regulations, veterinarians have the legal authority to use drugs in an extra-label manner if the situation warrants it. The federal government has limited legal mandate to enforce more restrictive directives aimed at limiting development of antimicrobial resistance when they appear on veterinary pharmaceutical labels.

- Ceftiofur resistance was most frequent in chicken *E. coli* and in chicken *Salmonella* (multiple serovars) as well as in clinical[26] turkey *Salmonella* isolates and bovine *S.* Newport isolates.

- Ceftiofur-resistant *S.* Heidelberg isolates were recovered from clinical samples from various animal species and were most common in our active surveillance findings in abattoir and retail chicken samples.

- For humans, the prevalence of ceftiofur resistance was highest for the serovar Heidelberg in comparison to all the other *Salmonella* serovars.

- Clinical *S.* Bredeney turkey isolates are of particular concern because they showed ceftiofur resistance in conjunction with resistance to many other antimicrobials (AKSSuT+A2C+GEN with additional intermediate susceptibility or resistance to ceftriaxone). To date, S. Bredeney is rare in humans in Canada and has only been observed in 0.1% (17/15974) of all Salmonella isolates from humans submitted to CIPARS since 2003. The AKSSuT+A2C+GEN resistance phenotype has not yet been detected among human Bredeney cases.

- Ceftiofur resistance in *S.* Newport from bovine clinical samples was frequently associated with resistance to other drugs (ACKSSuT+A2C with occasional resistance to gentamicin). Only 9% of all human *S.* Newport were ceftiofur-resistant, but these were all multidrug resistant (ACSSuT+A2C or ACKSSuT+A2C), and one was additionally resistant to nalidixic acid.

- Four human *S.* Concord strains recovered in 2006 from three different provinces were found to be resistant to ceftiofur and had the A2C-AMP resistance pattern. This serovar has never been detected in isolates from animals or food by CIPARS and only one other isolate, a susceptible strain, was previously detected from humans in 2003.

- Information from C-EnterNet in 2005-2006 indicated that the two cases of salmonellosis with cephalosporin resistance were domestically acquired (Box 5).

- The estimated human exposure to ceftiofur-resistant *S.* Heidelberg (Figure 40) from retail chicken has varied since 2003 according to[27]:

  1) *Salmonella* prevalence in chicken,
  2) the proportion of *Salmonella* that are *S.*Heidelberg,
  3) the proportion of *S.* Heidelberg that are ceftiofur resistant

  Between 2003 and 2004, the estimated human exposure to ceftiofur-resistant *S.* Heidelberg increased in Ontario, driven mainly by an increase in the proportion of ceftiofur-resistant *S.* Heidelberg strains present on retail chicken (Figure 40). Simultaneously in Québec, a decline in estimated human exposure was observed but was primarily explained by the decline in prevalence of *S.* Heidelberg on retail chicken during this period. A noticeable drop in exposure was then observed in both Ontario and Québec in 2005 and 2006 due to the decrease in the proportion of ceftiofur-resistant *S.* Heidelberg strains present on retail chicken. This drop followed a voluntary withdrawal of ceftiofur use in Québec chicken hatcheries in February 2005[28]. Preliminary data for 2007 indicate a possible rise in ceftiofur-resistant *S.* Heidelberg strains from retail chicken in both Ontario and Québec. Since 2005[29], human exposure to ceftiofur-resistant *S.* Heidelberg from chicken purchased in Saskatchewan was minimal as a result of the low proportion of ceftiofur-resistant *S.* Heidelberg strains and lower *S.* Heidelberg prevalence in chicken purchased in this province.

- There is a temporal correlation between the estimated human exposure to ceftiofur-resistant S. Heidelberg strains from retail chicken and the incidence of human cases related to this type of strain in Ontario, Québec, and Saskatchewan (Pearson correlation coefficient 0.91, $p<0.0001$, Figure 41).

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[26] Clinical animal isolates are obtained through passive surveillance. Specimens are originally submitted by veterinarians or producers to local or provincial laboratories and may include, in addition to sick animals, environmental samples or samples from non diseased animals from the same herd.

[27] The amount of chicken purchased or consumed or handled annually may also influence human exposure. This variable was held fixed in our analysis at 52 chicken purchases per year.

[28] *Salmonella* Heidelberg – Ceftiofur-Related Resistance in Human and Retail Chicken Isolates: http://www.phac-aspc.gc.ca/cipars-picra/heidelberg/heidelberg-eng.html.

[29] The year when retail surveillance was initiated in Saskatchewan.

- Observations after 2005 from Québec and Ontario tend to be similar. In the absence of drug use data in broiler chickens in Canada, it cannot be determined if the withdrawal of ceftiofur in Québec in 2005 subsequently led Ontario broiler chicken hatcheries to change their use of ceftiofur. The fact that there are animal and food exchanges between provinces could partly explain the similarities. A proportion of Ontario commercial broiler chickens are raised from hatching eggs produced in Québec[30] and some retail chicken meat sold in Ontario could have come from Québec chickens and vice versa.

- While there were similarities between Québec and Ontario, significant differences in ceftiofur resistance between the two provinces were also observed in 2006 among retail chicken *E. coli* isolates (refer to retail *E. coli* chicken section). Ceftiofur resistance did not decrease in Ontario to the level observed in Québec after the voluntary withdrawal.

- Exposure to sources of contamination other than chicken or from imported food may also play a role in the resistance observed in human *S.* Heidelberg isolates. For example, eggs can be imported from the US, for which we have no drug use or antimicrobial resistance information. Data published by the National Antimicrobial Resistance Monitoring System in the US (NARMS) indicated that 25% of the *Salmonella* isolates recovered from retail chicken in 2004 were resistant to ceftiofur[31]. These factors complicate the interpretation of the effect of the voluntary withdrawal of ceftiofur in Québec chicken hatcheries on the incidence of these strains in humans.

- Human consumption of second and third-generation cephalosporins (as dispensed by retail pharmacies) has decreased since 2000 and does not correlate with the fluctuation of ceftiofur resistance observed in human *S.* Heidelberg isolates[32]. However, hospital drug consumption data was not available at the time of analysis.

- Molecular work performed by the National Microbiology Laboratory (NML) and the Laboratory for Foodborne Zoonoses (LFZ) indicated that resistance to ceftiofur in chicken *Salmonella* and *E. coli* in Canada is generally mediated by the plasmid-encoded *Amp*C-type CMY enzymes, indicating that genetic elements of resistance can be transferred horizontally between the two genera (Ashleigh *et al.*, 2008) (Box 6).

- A study conducted by NML (Ashleigh *et al.*, 2008) examined the genetic relationship between *S.* Heidelberg isolates from retail meat, abattoir, and clinical human and animal specimens. There was little genetic diversity at the chromosomal level among the *S.* Heidelberg isolates from all sources and no suitable genetic trait was identified to permit tracking or identification of sources of human *S.* Heidelberg infections. Nevertheless, the rarity with which *S.* Heidelberg is recovered from other food-animal sources such as cattle or pigs, as well as results from outbreak investigations and case-control studies (Currie *et al.*, 2005; MacDougall *et al.*, 2004), suggest that chicken products are the most likely source of human infection with *S.* Heidelberg in Canada.

Limitations

- Apart from anecdotal information and one published study, there is very little information available on drugs used by Canadian chicken hatcheries and growers. This data gap prevents us from fully determining the impact of subtle changes in the level of ceftiofur use on resistance observed among bacteria recovered from Canadian chickens.
- On-farm drug use and antimicrobial resistance surveillance (including at the hatchery level) as well as research are needed to further understand the impact of agriculture usage of antimicrobials on public health.

- Labelling of retail meat products does not readily identify the farm of origin of the animal(s) from which the meat has been produced[33]. Tracing the source of meat to the animal or lot of production requires investigation and is particularly challenging in the case where animals (or hatching eggs) are born (or produced) in a country different from where they were raised or finished.

[30] Agriculture and Agri-Food Canada : http://www.agr.gc.ca/poultry/hatc-couv_e.html.

[31] NARMS Retail Meat Annual Report 2004: http://www.fda.gov/cvm/NARMSReport2004.htm.

[32] *Salmonella* Heidelberg – Ceftiofur-Related Resistance in Human and Retail Chicken Isolates: http://www.phac-aspc.gc.ca/cipars-picra/heidelberg/heidelberg-eng.html.

[33] Canada foodtracking system allows the investigation of outbreaks and the recall of food products but relies on information not readily available to consumers or CIPARS field workers.

Summary

- There is growing evidence that chicken meat is a major source of human infection with *S.* Heidelberg, including ceftiofur-resistant strains, and that ceftiofur resistance in chicken *E. coli* parallels the ceftiofur resistance in *S.* Heidelberg in Québec.

- To our knowledge, Québec is the only province that took a voluntary action to stop the extra-label use of ceftiofur in hatcheries. However, industry has reported a return to using ceftiofur on a limited basis in hatcheries in Québec in 2007, and this drug was likely used elsewhere in Canada and the USA. This drug is also labeled for use in turkeys in Canada.

- Although ceftiofur resistance was mainly a concern in *S.* Heidelberg, the emergence of ceftiofur resistance in other serovars from various animal species, and in the ubiquitous enteric bacterium *E. coli*, together with the fact that genetic resistance elements can be transferred horizontally, strengthens the need for the development of effective prudent use guidelines in all animal species, including in those commodities where a label exists for ceftiofur.

Activities

- We will continue to monitor and communicate the situation through our surveillance data and data from C-EnterNet.

- CIPARS retail surveillance is being expanded to include additional provinces to better describe regional similarities and differences. The addition of turkey meat to *Active Retail Surveillance* is currently under consideration.

- To acquire drug use information in conjunction with farm-level antimicrobial resistance data, CIPARS initiated an *On-Farm Surveillance* component in swine in 2005-2006, and is negotiating to expand this component to the broiler chicken industry. A collaborative beef project[34] supported by CIPARS also began in Alberta and Saskatchewan in 2007.

- Continuation of characterization of genetic elements of resistance from human and agri-food isolates is planned.

- Health Canada's Veterinary Drugs Directorate has revised the ceftiofur prescription labels to indicate that ceftiofur products are not recommended for use outside of the label specification. However, under provincial regulations, veterinarians have the legal authority to use drugs in an extra label manner if the situation warrants it. The federal government has limited legal mandate to enforce more restrictive directives aimed at limiting the development of antimicrobial resistance when they appear on veterinary pharmaceutical labels.

- CIPARS supports and encourages efforts like those that were undertaken in 2005 by Québec to limit the emergence and spread of cephalosporin-resistant *S.* Heidelberg and *E. coli* from poultry to humans, via reductions in ceftiofur use. CIPARS and PHAC will continue discussions with the provincial and industry representatives to promote similar action at a national level.

[34] Collaborators: Agriculture Agri-Food Canada, University of Calgary, Feedlot Health Management Services Ltd, Alberta Agriculture and Food, Colorado State University, Public Health Agency of Canada. Funding agencies: Beef Cattle Research Counsil, Alberta Beef Producers, Advancing Canadian Agriculture and Agri-Food Program. In-kind contribution: Public Health Agency of Canada, Agriculture and Agri-Food Canada.

Table 26. Ceftiofur resistance in *E. coli* and various *Salmonella* serovars; *CIPARS*, 2002-2006.

Bacteria	Project	Avian	Bovine	Canine	Chicken	Equine	Porcine	Turkey	Human
E. coli	Abattoir		4/668 (0.6%)		143/710 (20.1%)		1/611 (0.2%)		
	Retail		9/1422 (0.6%)		274/1349 (20.3%)		13/1083 (1.2%)		
S. Agona	Clinical		2/8 (25%)					1/5 (20%)	8/262 (3.1%)
	Abattoir				2/13 (15.4%)				
	Retail				2/6 (33.3%)				
S. Anatum	Clinical							1/3 (33.3%)	2/61 (3.3%)
S. Anatum var. 15+	Clinical								1/2 (50%)
S. Bardo	Clinical								1/13 (7.7%)
S. Berta	Clinical								8/84 (9.5%)
S. Bovismorbificans	Retail				1/1 (100%)				
S. Bredeney	Clinical	1/1 (100%)			1/1 (100%)			17/23 (73.9%)	
S. Concord	Clinical								4/5 (80%)
S. Derby	Clinical						4/117 (3.4%)		
	Abattoir				1/2 (50%)		1/248 (0.4%)		
S. Enteritidis	Clinical								10/2219 (0.5%)
S. Hadar	Clinical				1/19 (5.3%)				3/349 (0.9%)
S. Heidelberg	Clinical	6/43 (14%)	4/30 (13.3%)	2/15 (13.3%)	22/203 (10.8%)	7/188 (3.7%)		14/69 (20.3%)	485/1992 (24.3%)
	Abattoir				51/227 (22.5%)				
	Retail				66/167 (39.5%)				
S. I -:eh:2	Clinical		2/2 (100%)						
S. I -:r:2	Clinical								
S. I 13,23:b:-	Clinical								1/1 (100%)
S. I 19:-:-	Clinical						2/2 (100%)		
S. I 4,12:-:-non motile	Clinical								1/1 (100%)
S. I 4,12:i:-	Clinical								2/24 (8.3%)
S. I 4,5,12:-:1,2	Clinical								1/2 (50%)
S. I 4,5,12:b:-	Clinical								1/83 (1.2%)
S. I 4,5,12:i:-	Clinical								13/158 (8.2%)
S. I 4:-:-	Abattoir				1/1 (100%)				
S. I 4:-:2	Clinical				1/3 (33.3%)				
S. I 4:i:-	Clinical			1/1 (100%)	2/3 (66.7%)		1/14 (7.1%)		
	Abattoir				3/19 (15.8%)				
S. I 4:r:-	Abattoir				2/2 (100%)				
S. I 6,7,14:r:-	Abattoir				1/1 (100%)				
S. I 6,8:-:x	Clinical						1/1 (100%)		
S. I O:4,12(:i:-)	Clinical								1/1 (100%)

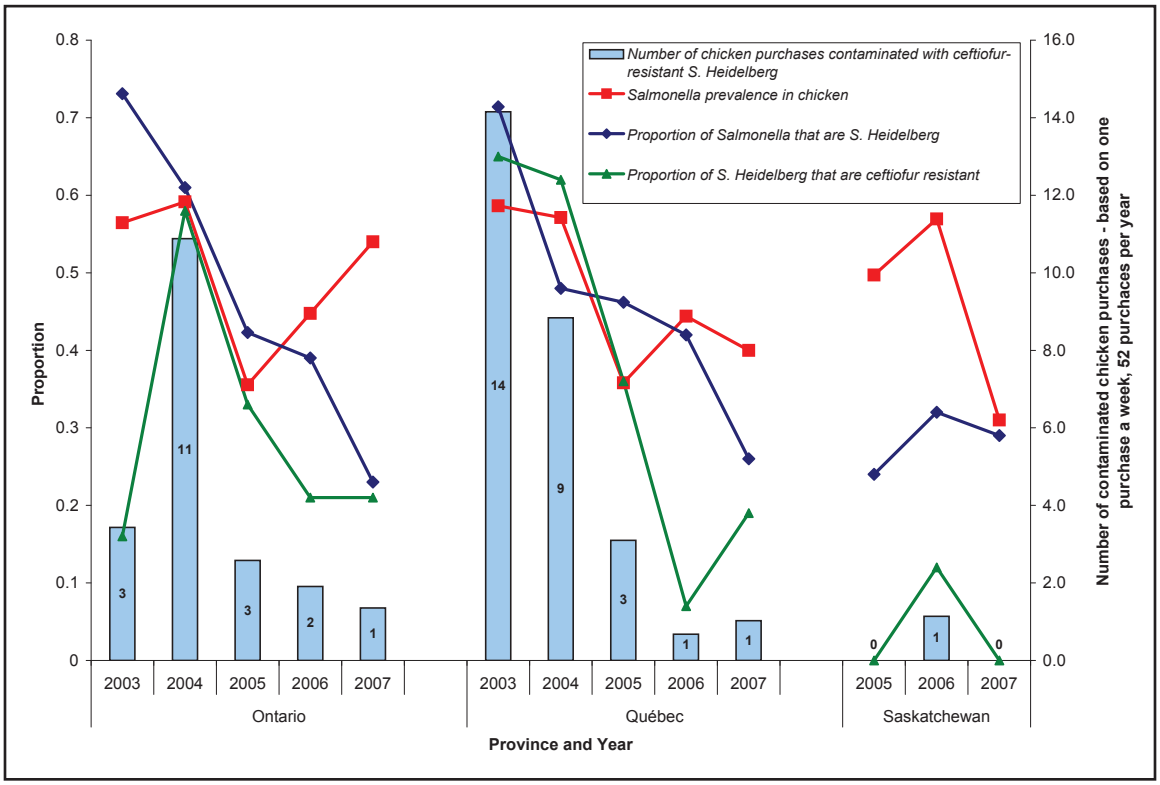
Note: This table is of those species/serovars where ceftiofur resistance was detected at least once. Ceftiofur resistance was also present in 1/1 S. Newport isolate from a caprine clinical sample, 1/3 isolates S. Heidelberg from cervid clinical samples, and 1/1 S. Newport isolate and 1/5 S. Typhimurium var. 5- isolates from ovine clinical samples.

Table 26 (continued). Ceftiofur resistance in *E. coli* and various *Salmonella* serovars; *CIPARS*, 2002-2006.

Bacteria	Project	Avian	Bovine	Canine	Chicken	Equine	Porcine	Turkey	Human
S. I OR:e,h:1,2	Clinical								1/2 (50%)
S. I Rough-O:-:-	Clinical								1/4 (25%)
S. Infantis	Clinical			1/2 (50%)			1/53 (1.9%)	4/6 (66.7%)	7/228 (3.1%)
	Abattoir				5/15 (33.3%)		1/77 (1.3%)		
	Retail				1/9 (11.1%)				
S. Johannesburg	Clinical						1/3 (33.3%)		
S. Kentucky	Clinical		2/144 (1.4%)						2/28 (7.1%)
	Abattoir				10/185 (5.4%)				
	Retail				5/61 (8.2%)				
S. Kiambu	Clinical	1/3 (33.3%)							3/36 (8.3%)
S. Litchfield	Clinical	1/1 (100%)				1/1 (100%)		3/5 (60%)	13/67 (19.4%)
S. London	Clinical								1/14 (7.1%)
S. Mbandaka	Clinical		2/11 (18.2%)			8/14 (57.1%)	1/27 (3.7%)		2/69 (2.9%)
S. Montevideo	Clinical					1/1 (100%)			1/99 (1%)
S. Muenchen	Clinical		1/8 (12.5%)						
S. Newport	Clinical		98/104 (94%)			1/12 (8%)			55/609 (9%)
S. OR:m.t:-	Clinical								1/1 (100%)
S. Ohio	Clinical						1/15 (7%)		
S. Oranienburg	Clinical								3/173 (2%)
	Abattoir				1/1 (100%)				
S. Pakistan	Clinical	1/1 (100%)							
S. Paratyphi B var. L(+) tartrate+	Clinical								1/161 (1%)
S. Putten	Clinical								1/1 (100%)
	Retail				1/1 (100%)				
S. Saintpaul	Clinical		2/4 (50%)						
S. Schwarzengrund	Clinical						3/17 (18%)		
	Abattoir				1/17 (6%)				
S. Senftenberg	Clinical								1/34 (3%)
S. Stanley	Clinical								1/133 (1%)
S. Thompson	Clinical								11/408 (3%)
	Abattoir				5/19 (27%)				
S. Typhi	Clinical								3/533 (0.6%)
S. Typhimurium	Clinical		32/308 (10%)	1/8 (12%)		3/71 (4%)	9/453 (2%)	1/5 (20%)	51/2300 (2%)
	Abattoir				2/20 (10%)				
	Retail				1/4 (25%)				
S. Typhimurium var. 5-	Clinical		43/325 (13%)				1/339 (0.3%)		
	Abattoir				1/7 (14%)				
	Retail				5/7 (71%)				
S. Uganda	Clinical		1/5 (20%)						1/42 (2%)

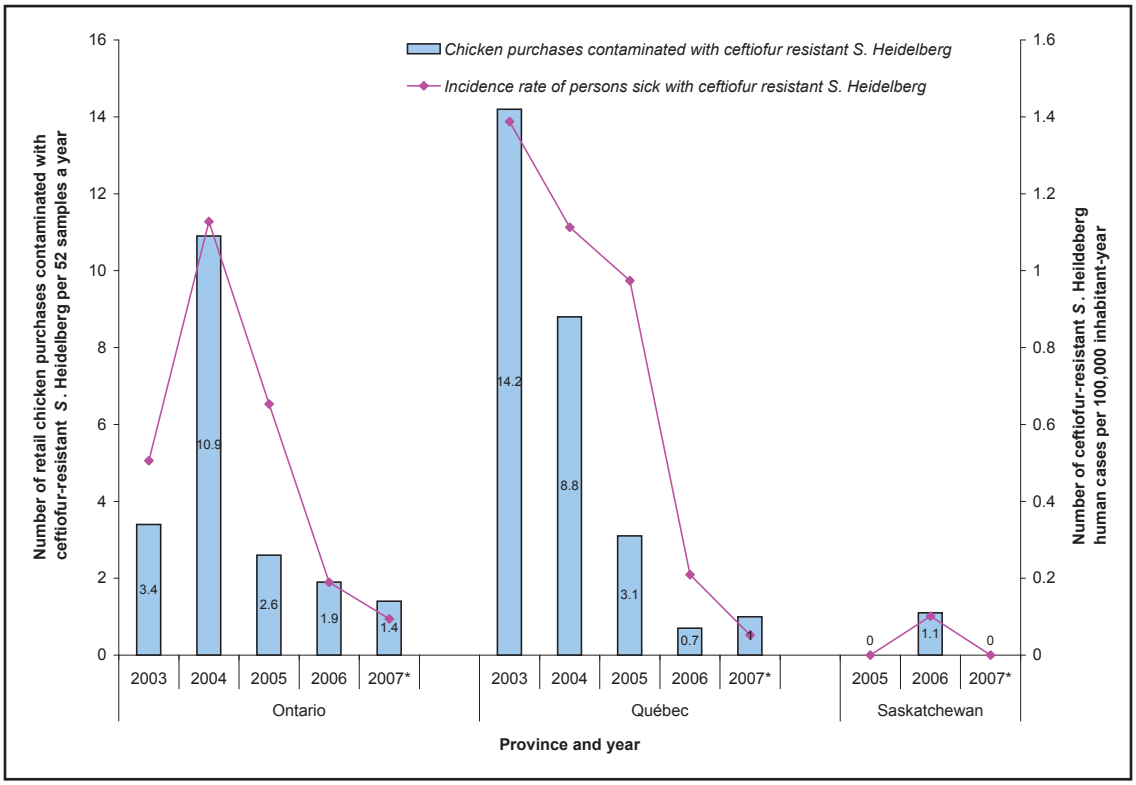
Note: This table is of species/serovars where ceftiofur resistance was detected at least once. Ceftiofur resistance was also present in 1/1 S. Newport isolate from a caprine clinical sample, 1/3 isolates S. Heidelberg from cervid clinical samples, and 1/1 S. Newport isolate and 1/5 S. Typhimurium var. 5- isolates from ovine clinical samples.

Figure 40. Estimated likelihood of human annual exposure to retail chicken contaminated with ceftiofur-resistant *S. Heidelberg*.



Note: Number of chicken purchases contaminated with ceftiofur-resistant *S.* Heidelberg: estimated number of retail chicken samples contaminated with ceftiofur-resistant *S.* Heidelberg strains, for someone who would have purchased fresh chicken once a week over the year (52 samples). *Salmonella* prevalence in chicken: yearly *Salmonella* prevalence as estimated by CIPARS surveillance in retail meat and corrected for CIPARS new recovery method (Box 4). The 2007 estimates are based on preliminary data and are subject to change.

Figure 41. Estimated human annual exposure to retail chicken contaminated with ceftiofur-resistant *S.* Heidelberg strains compared to the incidence of human ceftiofur-resistant *S.* Heidelberg cases, based on purchasing chicken once a week.



Note: 2007 data are preliminary and subject to change.

Fluoroquinolone Resistance in Humans and Animals

Background and Rationale for Concern

- Fluoroquinolones are an important class of antimicrobials used in human medicine (classified as Category I), to treat a wide variety of infections including: urinary tract, lower respiratory tract, and skin infections, as well as severe infections caused by *Campylobacter* spp. and *Salmonella* spp. Fluoroquinolones are often used as a first-line treatment in unspecified gastroenteritis.

- In Canada, fluoroquinolones are approved for use in veterinary medicine for companion animals. Enrofloxacin and danofloxacin were approved in 2004 and 2005 respectively for therapeutic use in cattle to treat infections caused by *Mannheimia haemolytica and Pasteurella multocida*[35], [36]. Enrofloxacin was approved for use in turkeys in 1987 but this approval was withdrawn in 1997. No fluoroquinolones are approved for non-therapeutic use in Canadian food-animals.

- In the US, fluoroquinolones were approved for use in poultry, but this approval has since been removed due to concerns about increased resistance to fluoroquinolones in *Campylobacter* isolates from retail chicken and the potential for these resistant *Campylobacter* to be transferred to humans (Moore *et al.*, 2006). Enrofloxacin

[35] http://www.hc-sc.gc.ca/dhp-mps/vet/faq/baytril_qa-qr-eng.php

[36] Health Canada has required fluoroquinolone manufacturers to include explicit directions including WARNING statements on the product label. The products must not be used in an extra-label manner in any species (including other bovines: veal calves and dairy cattle) and the mandatory withdrawal period must be strictly observed. These products are available only by prescription from a veterinarian and should be used only for treating relapse cases of bovine respiratory disease after initial treatments have failed.

was approved in the US for use in feedlot cattle (1998[37]), dairy cattle less than 20 months of age (2008)[38], swine (2008)[39], and is also licensed for use in companion animals.

- Reduced susceptibility to fluoroquinolones (MICs ≥0.125 µg/ml) can result in fluoroquinolone therapeutic failure, thus limiting treatment options for bacterial disease (McCarron *et al.*, 1997; Helms *et al.*, 2002; Mølbak *et al.*, 1999). Resistance to fluoroquinolones has been most frequently reported in *Salmonella* spp. (Hald *et al.*, 2007), *Campylobacter* spp. (Hein *et al.*, 2003), and *E. coli* (Karlowsky *et al.*, 2003).

- There is currently debate regarding the ciprofloxacin resistance breakpoint for *Salmonella* spp. (Crump *et al.*, 2003), which the CLSI currently has set at ≥4 µg/ml (CLSI M100-S16). It has been recommended that it be changed to a breakpoint of ≥0.125 µg/ml (Aarestrup et al., 2003). DANMAP is currently using a resistance breakpoint of ≥0.125 µg/ml for both *Salmonella* spp. and E. coli (DANMAP, 2006). The European Committee on Antimicrobial Susceptibility Testing (EUCAST) has set the *Enterobacteriacea* resistance breakpoint for ciprofloxacin and most other fluoroquinolones at MIC greater than I ug/ml but also mentions that "*there is clinical evidence for ciprofloxacin to indicate a poor response in systemic infections caused by Salmonella spp. with low-level fluoroquinolone resistance (MIC>0.064 ug/L)*"[40]. CLSI states that fluoroquinolone treatment failure can be expected if the bacterial strain is nalidixic acid resistant. Quinolones have similar mechanisms of action, and resistance to one may confer resistance to another. Resistance to the quinolone nalidixic acid usually precedes resistance to fluoroquinolones. There is usually a high correlation between nalidixic acid resistance and reduced susceptibility to ciprofloxacin (MICs ≥0.125 µg/ml).

- Plasmid-mediated quinolone resistance is observed globally in human and animal isolates of *E. coli* and *Salmonella* spp. Quinolone resistant determinants (*qnrA, qnrB,* and *qnrS*) can be associated with resistance to other antimicrobials (multidrug resistant phenotypes) (Li, 2005).

Surveillance Findings

- Most of the nalidixic acid resistance in human *Salmonella* isolates has been observed in *S.* Typhi, *S.* Paratyphi A and B, and *S.* Enteritidis (Table 27).

- Since 2003, little resistance to ciprofloxacin has been observed among human *Salmonella* isolates using the current CLSI breakpoint (MICs ≥4 ug/ml) (Table 27). Reduced susceptibility or resistance to ciprofloxacin (MICs ≥0.125 µg/ml) was much higher, particularly in S. Typhi, Paratyphi A and B, and *S.* Enteritidis isolates (Table 27).

- For human isolates, CIPARS data indicate that reduced susceptibility or resistance to ciprofloxacin (≥0.125 µg/ml) among *S.* Typhi and Paratyphi isolates has been increasing since 2003. Temporal fluctuations in ciprofloxacin reduced susceptibility or resistance have also been observed in *S.* Enteritidis. A greater proportion of S. Enteritidis isolates were susceptible in 2005 (Figure 42) likely as a result of a large outbreak of pansusceptible *S.* Enteritidis PT13. We also observed reduced susceptibility or resistance in other serovars such as *S.* Typhimurim, *S.* Newport, and *S.* Heidelberg (Table 27).

- Overall, 85% (161/189) of *S.* Paratyphi A isolates were showing reduced susceptibility or resistance to ciprofloxacin (≥0.125 µg/ml) compared to 10% (2/20) of *S.* Paratyphi B isolates.

- C-EnterNet, through their sentinel site in the Region of Waterloo in Ontario (Box 5) gathered travel information from human *Salmonella* and *Campylobacter* cases. Overall, only 8% (3/39 cases tested excluding outbreaks) of human non-travel-related *Salmonella* infections were nalidixic acid-resistant compared to 32% (12/37) of travel-related cases. Similarly, among *Campylobacter* infections, 8% (5/64 cases tested excluding outbreaks) of the non-travel-related cases were nalidixic acid-resistant compared to 54% (7/13 cases tested) of travel-related cases.

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[37] http://www.drugs.com/vet/baytril-100-enrofloxacin-100-mg-ml-antimicrobial-injectable-solution.html; http://www.fda.gov/cvm/CVM_Updates/NOELUUP.html

[38] http://www.cattlenetwork.com/Bayer_Content.asp?ContentID=211903; http://www.bayerdvm.com/resources/docs/FINAL%20-%20BL08185%20Q&A%20Brochure.pdf

[39] http://www.drugs.com/vet/baytril-100-enrofloxacin-100-mg-ml-antimicrobial-injectable-solution.html

[40] http://www.srga.org/eucastwt/MICTAB/MICquinolones.htm

- From 2000 to 2006, the amount of oral fluoroquinolones dispensed in the community has been increasing (Figure 42). Consumption varied greatly across the provinces (Section two – Antimicrobial Use) and was above the consumption levels of several European countries.

- In the agri-food isolates, generally very little resistance or reduced susceptibility to quinolones has been observed (Table 28). Among food-animals, most resistance has been observed in *Campylobacter* isolates from retail chicken (3% resistance to both ciprofloxacin and nalidixic acid).

- The highest levels of ciprofloxacin reduced susceptibility (MIC 0.125 to 2µg/ml) were observed in clinical *Salmonella* isolates from horses (38%, 143/372). None of these isolates were resistant to ciprofloxacin (≥4 µg/ml). Of those having reduced susceptibility, 97% (139/143) were *S.* Heidelberg. Overall, 74% (139/188) of the *S.* Heidelberg isolates from horses had reduced susceptibility to ciprofloxacin and were always multidrug resistant with the AMP-CHL-GEN-KAN-SSS-SXT pattern plus other antimicrobials. Of note, 98% (136/139) of these isolates with reduced susceptibility to ciprofloxacin were not resistant to nalidixic acid. The quinolone resistance was mediated by the plasmid-encoded *qnrB* gene. These isolates were clustered in Ontario.

Table 27. Nalidixic acid resistance, ciprofloxacin resistance (≥4 µg/ml), and ciprofloxacin reduced susceptibility or resistance (≥0.125 µg/ml) among human and animal isolates of *Salmonella* in Canada; *CIPARS*, 2002-2006.

Surveillance component and species (year)	*Salmonella* serovar	Number of isolates	Resistance to nalidixic acid N (%)	Resistance to ciprofloxacin ≥4 µg/ml N (%)	Reduced susceptibility or resistance to ciprofloxacin ≥0.125 µg/ml N (%)
***Surveillance of Human Clinical Isolates* (2003-2006)**					
Human[1]	Enteritidis	2219	390 (18)	0	388 (17)
	Heidelberg	1992	27 (1)	0	25 (1)
	Newport	609	15 (2)	0	16 (3)
	Paratyphi A and B	209	163 (78)	0	163 (78)
	Typhi	533	344 (64)	0	352 (66)
	Typhimurium	2300	42 (2)	6 (<1)	56 (2)
	Other	4631	216 (5)	5 (<1)	230 (5)
***Surveillance of Animal Clinical Isolates* (2002-2006)**					
Bovine	*Salmonella*[3]	933	0	0	0
Swine	*Salmonella*	1077	2 (<1)	0	6 (1)
Chickens	*Salmonella*	283	0	0	0
Turkeys	*Salmonella*	218	2 (1)	0	3 (1)
Equine	*Salmonella*	372	4 (1)	0	143 (38)
Other[2]	*Salmonella*	471	2 (<1)	0	6 (1)
***Abattoir Surveillance* (2002-2006)**					
Beef cattle	*Salmonella*	1	0	0	0
Swine	*Salmonella*	1157	0	0	0
Chickens	*Salmonella*	683	1	0	0
***Retail Meat Surveillance* (2003-2006)**					
Beef	*Salmonella*	2	0	0	0
Pork	*Salmonella*	9	0	0	0
Chicken	*Salmonella*	450	0	0	0
***On-farm Surveillance* (2006)**					
Swine	*Salmonella*	94	0	0	0

[1] Values not corrected for non-proportional submission scheme between provinces (See Appendix A.2).

[2] Other animal species with reduced susceptibility or resistance to ciprofloxacin (≥0.125 µg/ml) in *Salmonella* included avian (2), canine (1), feline (1) and reptile (2). Both isolates resistant to nalidixic acid were from reptiles.

[3] A future CIPARS publication will describe the serovar of these *Salmonella* isolates.

Table 28. Nalidixic acid and ciprofloxacin resistance among *E. coli, Campylobacter,* and *Enteroccocus* isolates and reduced susceptibility or resistance to ciprofloxacin in *E. coli* from the agri-food sector; *CIPARS*, 2002-2006.

Surveillance component and species (year)	Bacteria	Number of isolates	Resistance to nalidixic acid N (%)	Resistance to ciprofloxacin ≥4 µg/ml N (%)	Reduced susceptibility or resistance to ciprofloxacin ≥0.125 µg/ml N (%)
***Abattoir Surveillance* (2002-2006)**					
Beef cattle	*E. coli*	667	2 (<1)	1 (<1)	2 (<1)
	Campylobacter[1]	258	11 (4)	1 (<1)	N/A
Swine	*E. coli*	1119	4 (<1)	1 (<1)	4 (<1)
Chickens	*E. coli*	1782	54 (3)	0	50 (3)
***Retail Meat Surveillance* (2003-2006)**					
Beef	*E. coli*	1423	4 (<1)	0	4 (<1)
	Enterococcus[2]	101	n/a	2 (2)	N/A
Pork	*E. coli*	1086	2 (<1)	0	1 (<1)
	Enterococcus[2]	100	n/a	2 (2)	N/A
Chicken	*E. coli*	1352	30 (2)	0	29 (2)
	Campylobacter[3]	1060	37 (3)	32 (3)	N/A
	Enterococcus	1409	n/a	15 (1)	N/A
***On-farm Surveillance* (2006)**					
Swine	*E. coli*	2197	2 (<1)	1 (<1)	1 (<1)
	Enterococcus	867	n/a	13 (2)	N/A

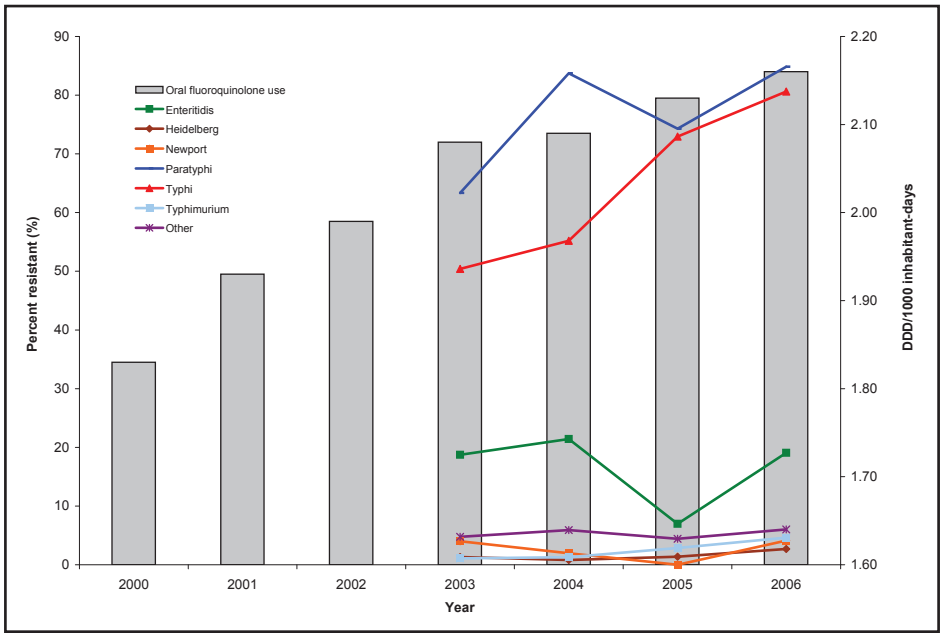
Note: N/A= Not applicable for *Campylobacter* and *Enterococcus*.

[1] Isolation of *Campylobacter* from cattle at slaughter began in 2005. The data shown here are for 2005 and 2006. Some of these isolates were *Campylobacter* spp. which may include some species intrinsically resistant to nalidixic acid.

[2] Isolation of *Enterococcus* from beef and pork at retail was only done in 2003.

[3] All nalidixic-resistant chicken *Campylobacter* were *C. jejuni* or *C. coli*.

Figure 42. Temporal trends in ciprofloxacin reduced susceptibility or resistance (≥0.125 µg/ml) among the main human *Salmonella* serovars and human consumption of oral fluoroquinolones dispensed by retail pharmacies in Canada; 2000-2006.



Note: Source of oral fluoroquinlone consumption data: IMS Health. *Salmonella* Typhi and *S.* Paratyphi are primarily travel-related. Some *S.* Enteritidis may also be travel-related.

Summary

- C-EnterNet data indicate that most of the human cases of nalidixic acid resistant *Salmonella* were travel-related (12/15 cases).
- *S.* Typhi and *S.* Paratyphi, where higher levels of quinolone resistance were observed, were likely acquired abroad. However, travellers are often prescribed fluoroquinolones before leaving the country (Thielman *et al.*, 2004) and the impact of this drug use practice on the development of gastroenteritis with *Salmonella* strains with reduced susceptibility to ciprofloxacin has not been studied.
- Fluoroquinolone consumption in the community in Canada is increasing and varies between the provinces. Prudent use in human medicine is important to prevent/limit the emergence or spread of quinolone resistant strains.
- At this time, there is little evidence of quinolone resistance or reduced susceptibility in isolates derived from food-animals but prudent use is necessary to prevent/limit the emergence or spread of quinolone resistant strains.
- Ciprofloxacin resistance among *Salmonella* clinical isolates from horses was common, particularly among *S.* Heidelberg isolates. Most of the resistant *Salmonella* isolates from horses were geographically clustered, an indication of local clonal spread. At this time, data are being gathered to investigate further.

Activities

- Since the approval of enrofloxacin and danofloxacin for use in cattle, CIPARS data have been used for post-approval monitoring for fluoroquinolone resistance by the VDD of Health Canada.
- CIPARS has looked at fluoroquinolone resistance in bacteria from retail (milk-fed and grain-fed) veal as well as from turkeys. This information was needed to evaluate the prevalence levels in these animal species not included in our regular surveillance programs. Results will be presented when the analysis is completed.
- In Saskatchewan, a study was conducted to compare antimicrobial resistance profiles of *Campylobacter* strains from retail chicken and humans (Box 7). Saskatchewan was chosen for the research because of the greater availability and increased representativeness of human *Campylobacter* isolates in that province and because of the concurrent availability of CIPARS retail surveillance information.
- Molecular characterization of resistance determinants has recently been undertaken for *E. coli* and *Salmonella* isolates of agri-food origin.

Macrolide Resistance in Humans and the Agri-Food Sectors

Background and Rationale for Concern

- Despite the emergence of macrolide resistance globally, this antimicrobial class may represent an alternative to fluoroquinolones as a first-line treatment, especially for *Campylobacter* infections (Moore *et al.*, 2006).
- Macrolides are commonly used as empirical therapy for patients with suspected pneumococcal infections and are the second most prescribed class of antimicrobials. To prevent macrolide treatment failures, guidelines recommend that people who have been exposed to macrolides in the previous three months should not be prescribed any macrolides (Daneman *et al.*, 2006).
- Macrolides are approved for use in food-animals from Canada, both for individual therapy as well as for group medication.
- Studies performed on human clinical *Campylobacter* jejuni isolates from Québec between 1985 and 1997 (n=291) did not identify any resistance to the macrolide erythromycin (Gaudreau *et al.*, 1998). Another report

published by the same authors indicated that resistance among *Campylobacter jejuni* isolates was present in 1998, 1999, 2000, and 2001 in 3% (n=2/62), 2% (n=1/60), 1% (n=1/72) and 12% (n=6/51) of the strains tested, respectively (Gaudreau *et al.*, 2003).

- Consumption of poultry meat, exposure to pets or other farm animals, and wildlife are possible sources of *Campylobacter* infections (Michaud *et al.*, 2004; C-EnterNet, 2006[41]). Environmental sources, especially untreated drinking water, are currently receiving increased attention in the scientific litterature.

- Data from a Québec study conducted in 1998 and 1999 indicated no resistance to erythromycin among eight *C. coli* recovered from broiler chicken caecal samples, 7% (13/180) resistance in *C. jejuni* from the same source, and 61% (59/96) resistance in *C. coli* from swine caecal samples. Erythromycin resistance was observed in 12% (2/16) of *C. coli* and 9% (2/23) of *C. jejuni* from human clinical isolates. Rates of clindamycin resistance were similar to those observed for erythromycin (Guévremont *et al.*, 2006).

- Data from an Alberta study in 2001 indicated no resistance to erythromycin among 104 *Campylobacter* isolates recovered from poultry meat (Kos *et al.*, 2006).

Surveillance Findings

- For retail chicken, the CIPARS 2005 Annual Report described overall rates of 16% resistance to macrolides in *C. coli* and 6% resistance in *C. jejuni* from chicken purchased in Ontario and Québec (CIPARS, 2005[42]). CIPARS surveillance in 2006 indicated that overall resistance to macrolides was 9% for *C. coli* and 4% for *C. jejuni*. Temporal analyses showed a decrease in the prevalence of resistance to azithromycin[43] in *Campylobacter* isolates recovered in the province of Québec between 2003 and 2006, but no significant changes in Ontario.

- *Campylobacter* isolates recovered from beef cattle at abattoir indicated no resistance to macrolides from isolates collected between September 2005 and December 2006.

- C-EnterNet data indicated that azithromycin resistance in human *Campylobacter* was only detected among *C. coli* (Box 5).

- Human consumption of macrolides in the community has increased for azithromycin and clindamycin, but has decreased for erythromycin since 2000 (Section two – Antimicrobial Use).

Summary

- Macrolide resistance has been observed in retail chicken, but the prevalence is either decreasing or is at a stable level since 2003.

- At this time, we have not detected macrolide resistance in *Campylobacter* isolates collected from beef cattle at slaughter.

- Newer macrolides are being increasingly dispensed by retail pharmacies for use in humans. Prudent use in humans is encouraged to ensure this class of antimicrobials remains effective (Section two – Antimicrobial Use).

Activities

- CIPARS is studying options for establishing antimicrobial resistance surveillance of human *Campylobacter* isolates.

- To compare the resistance profiles, a study on antimicrobial resistance in *Campylobacter* from chicken and humans has been undertaken in Saskatchewan (Box 7).

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[41] http://www.phac-aspc.gc.ca/c-enternet/index-eng.php.

[42] http://www.phac-aspc.gc.ca/cipars-picra/index_e.html.

[43] Azythromycin was used as a representative for the macrolide class in this temporal analysis.

- The recent addition of CIPARS *On-Farm Surveillance* in swine and beef cattle will provide information on drug use in these commodities. CIPARS is also evaluating options for the acquisition of drug use information in chickens.

Vancomycin Resistance in the Agri-Food Sectors: Absence

Background and Rationale for Concern

- Vancomycin resistance in human nosocomial *Enterococcus* infections (VRE) is increasingly observed world-wide (Centers for Disease Control and Prevention, 2000; Reacher *et al.*, 2000). In comparison to other countries, Canadian VRE rates have been low, but recent data indicate a rise in the incidence of VRE in Canada[44].

- In Europe, vancomycin resistance in animals was related to the use of the growth promoter avoparcin. Avoparcin was banned from use in food-animals in Denmark in 1995 and in all of the European Union in 1997 (WHO, 2003)[45]. In Denmark, vancomycin resistance in broilers and swine decreased subsequently.

- Avoparcin has never been approved for use in food-animals in North America.

Surveillance Findings

- CIPARS has tested 1465 retail chicken *Enterococcus* isolates since 2003 and has detected no vancomycin resistance. Vancomycin resistance was also not detected in *Enterococcus* strains from retail pork (n=99) and beef (n=100) recovered in 2003, or retail turkey strains (n=16) recovered in 2005.

- Results from tests performed in 2006 on 867 isolates recovered from *On-farm Surveillance* in swine indicate no resistance to vancomycin.

Summary

- To date there is no evidence that food-animals are a source of vancomycin-resistant *Enterococcus* strains for humans in Canada.

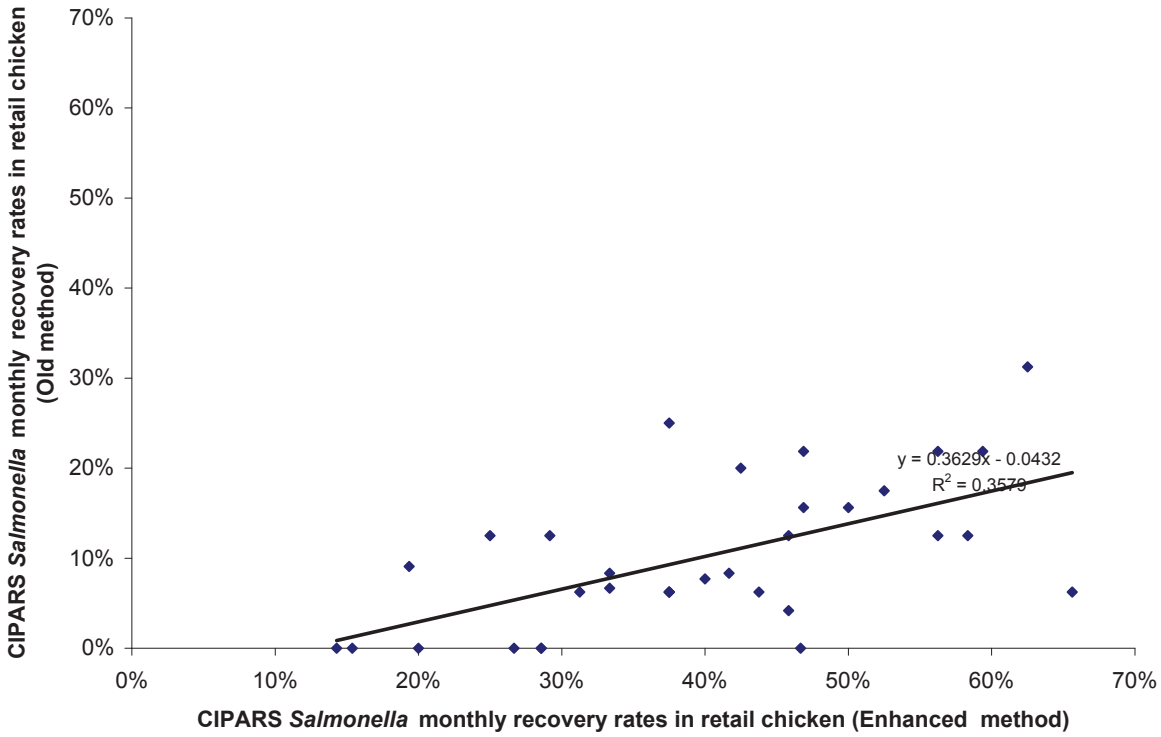
[44] The Canadian Nosocomial Infection Surveillance Program. http://www.phac-aspc.gc.ca/nois-sinp/projects/vre_e.html.

[45] Impacts of antimicrobial growth promoter termination in Denmark. http://www.who.int/salmsurv/en/Expertsreportgrowthpromoterdenmark.pdf.

Box 4. Comparison of recovery rate methods for retail chicken - Preliminary results.

Both CIPARS and C-EnterNet[46] surveillance programs test retail chicken products (legs skin on, breasts skin on respectively) for *Salmonella* spp. From 2003-2006, the CIPARS recovery method incubated the rinsate from the whole chicken leg overnight, whereas the C-EnterNet method incorporated a 30 gram piece of breast in the overnight enrichment of the rinsate sample. Initial data shared between the programs suggested that the C-EnterNet method was much more sensitive in detecting *Salmonella* spp. CIPARS has slightly modified the C-EnterNet method by incorporating the whole chicken leg in the enrichment of the rinsate sample overnight. CIPARS has been running the conventional CIPARS method in parallel with the new enhanced method in pork and chicken since September 2006. Initial results indicated that the *Salmonella* recovery rate in chicken was higher when the new enhanced method was applied (Figure A). Recovery rates in retail pork also slightly increased from less than 1% to 2%.

Figure A. *Salmonella* recovery rates from retail chicken using two different recovery methods.



It is a priority for CIPARS to utilize the most cost-effective and sensitive methodology to measure the actual exposure of Canadians to pathogens from animal and animal-derived foods. CIPARS has therefore adopted the new recovery method in 2007. Preliminary analysis indicated that the change in recovery method did not impact antimicrobial resistance prevalence estimates. CIPARS will follow both testing methods in parallel until we have enough information to accurately measure the impact of the method change on antimicrobial resistance prevalences. CIPARS will harmonize whereever possible, sampling, culture, and reporting methodology among surveillance programs. Differences in the various *Salmonella* recovery methods, sample type, or sampling techniques must be considered when comparing CIPARS recovery rates to those from other sources such as C-EnterNet, Canadian Food Inspection Agency, or United States Department of Agriculture.

[46] http://www.phac-aspc.gc.ca/c-enternet/index.html

Box 5. Results on Human *Salmonella* and *Campylobacter*; *C-EnterNet*, 2006.

C-EnterNet is a sentinel site enteric disease surveillance program that has been operating since 2005. It is a multi-partner initiative that is operated through the Public Health Agency of Canada. One of the main objectives of C-EnterNet is to develop improved methods for source attribution. At this time, C-EnterNet is operating in a single sentinel site: the Region of Waterloo, Ontario. The data presented here are from this unique site. Further details are available in the C-EnterNet annual report for 2006 at: http://www.phac-aspc.gc.ca/c-enternet/index.html.

C-EnterNet gathers human AMR data through laboratory submissions from notifiable enteric disease cases. C-EnterNet is using AMR testing as an additional method of strain subtyping. The data gathered by C-EnterNet are complementary to those collected by CIPARS. The sentinel site provides an opportunity to investigate enteric pathogens and conduct a detailed interview for each clinical case of disease caused by those pathogens, thus enabling further understanding of pathogen transmission and disease pathogenesis. The availability of more complete epidemiological information related to each *Salmonella* case provides insights on what may explain some CIPARS observations.

Overall, little resistance has been identified in human *Salmonella* and *Campylobacter* infections that were acquired domestically (Table A). Higher proportions of infections acquired through travel abroad were resistant to quinolones. Only domestic cases of salmonellosis demonstrated any resistance to cephalosporins. Both isolates that were resistant to cephalosporins were S. Oranienberg; one was PT8 (resistant to both cefoxitin and ceftiofur) and the other was an atypical phage type (resistant to ceftiofur only).

Table A. Human *Salmonella* and *Campylobacter*; *C-EnterNet*, 2006.

Serovar / Species	Class	Total isolates	Number of isolates with AMR data	Number (%) of quinolone resistant isolates		Number (%) of cephalosporin resistant isolates		Number (%) of macrolide resistant isolates
				Nalidixic acid	Ciprofloxacin	Cefoxitin	Ceftiofur	Azythromycin
Salmonella								
S. Typhi	Travel	1	1	1 (100)	0	0	0	NT
S. Paratyphi	Travel	5	4	3 (75)	0	0	0	NT
	Endemic	1	1	1 (100)	0	0	0	NT
S. Enteritidis	Travel	19	11	2 (18)	0	0	0	NT
	Endemic	14	12	1 (8)	0	0	0	NT
S. Heidelberg	Endemic	4	2	0	0	0	0	NT
	Outbreak	1	1	0	0	0	0	NT
S. Newport	Endemic	3	1	0	0	0	0	NT
S. Typhimurium	Endemic	15	9	0	0	0	0	NT
	Outbreak	1	1	0	0	0	0	NT
Other	Travel	24	21	6 (29)	0	0	0	NT
	Endemic	23	14	1 (7)	0	1 (7)	2 (14)	NT
Campylobacter								
C. coli	Travel	6	4	3 (75)	3 (75)	NT	NT	2 (50)
	Endemic	3	3	0	0	NT	NT	1 (33)
C. jejuni	Travel	20	9	4 (44)	2 (22)	NT	NT	0
	Endemic	103	60	4(7)	4(7)	NT	NT	0
C.lari	Travel	1	0	0	0	NT	NT	0
	Endemic	1	1	1 (100)	1 (100)	NT	NT	0
Unknown	Endemic	2	0	0	0	NT	NT	0

Note: NT=not tested.

[1] The MIC breakpoint used was ≥4 µg/ml.

Box 6. Preliminary findings on the molecular epidemiology of extended-spectrum cephalosporin resistance; *Laboratory for Foodborne Zoonoses*, 1999-2004.

In Canada, extended-spectrum cephalosporin (ESC) resistance in *Salmonella* from animals emerged several years ago. Since its identification, the Laboratory for Foodborne Zoonoses (LFZ) has been conducting research on this topic for several years (Allen *et al.*, 2002). The LFZ is examining the molecular epidemiology of ESC resistance in *Salmonella* and *Escherichia coli* from animals in relation with the bla_{CMY-2} gene, with expansion to the bla_{CTX-M} gene scheduled for 2008-2009.

A total of 18,605 *Salmonella* isolates from animals in Canada recovered between 1999 and 2004 were screened for antimicrobial resistance profiles compatible with ESC-resistance. From these, 652 were positive by Polymerase Chain Reaction (PCR) for the presence of the bla_{CMY-2} gene. The bla_{CMY-2} plasmids from 42 of these isolates were characterized in more detail showing three major genetic groups of plasmids associated with specific resistance profiles (i.e. one plasmid group encodes resistance to ESCs and other ß-lactams only, whereas the two other groups encode multidrug resistance including mostly ESCs and other ß-lactams, sulfonamides, trimethoprim, tetracycline, gentamicin, kanmycin/neomycin, and chloramphenicol). These bla_{CMY-2} plasmids were found in a large variety of *Salmonella* serovars, including among others Agona, Branderup, Bredeney, Derby, Enteritidis, Heidelberg, Infantis, Kentucky, Mbandaka, Newport, Reading, Typhimurium, and Typhimurium var. 5-. The finding of bla_{CMY-2} plasmids from the same group in different *Salmonella* serovars and of different groups in the same serovar clearly indicates these plasmids have spread horizontally and that their acquisition occurred repeatedly within at least some of the *Salmonella* serovars. No clear-cut association between a specific type of bla_{CMY-2} plasmid and *Salmonella* from a specific animal host species was observed.

We also examined bla_{CMY-2} plasmids from 9 pairs of *Salmonella* and *E. coli* isolates originating from the same 9 caecal chicken samples. Among these 9 pairs, one shared the same bla_{CMY-2} plasmid in the *E. coli* and the *Salmonella* (*S.* Kentucky), suggesting that a plasmid might have transferred between the two organisms *in vivo*, as previously demonstrated by Poppe *et al.* (2005) in turkey poults under experimental conditions. This particular plasmid seems widespread in *Salmonella* populations and we are currently checking its distribution in *E. coli* to assess if it occurred within the same pairs by chance, rather than through transfer *in vivo*.

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Box 7. Antimicrobial resistance of enteric *Campylobacter* isolates from human patients in Saskatchewan; 1996-2004.

Otto S[1], Daku D[2], Gow S[3], Nagle E [2], Campbell J[3], Levett PN[2], Doré K[4], McEwen S[1], Horsman GB[2]

Background: Antimicrobial resistance is a growing concern that may increase the burden of illness of campylobacteriosis and adversely affect clinical treatment options. Several animal species are sources of *Campylobacter* and the presence of AMR in human cases warrants closer examination of AMR from animals and animal-derived food products (particularly poultry) to support public health policy decisions regarding veterinary antimicrobials. Currently, representative laboratory surveillance data on *Campylobacter* and AMR is scant across Canada, with the exception of the Saskatchewan (SK) Provincial Laboratory, which tests a large proportion of provincially-reported *Campylobacter* cases. This study gathered baseline information on magnitude and trends of AMR in *Campylobacter* isolated from enteric specimens submitted to SK Provincial Laboratory.

Methods: Descriptive analysis was performed on standardized data (species, sample submission date, antimicrobial susceptibility profiles, regional health authority of origin, patient age, and gender) associated with SK *Campylobacter* isolates 1996-2004.

Results: Antimicrobial susceptibility testing was performed on 1208/1736 human strains of *Campylobacter* spp. isolated 1996 – 2004, using E-tests. Most of the 1736 strains (82.9%) were *C. jejuni*, but *C. coli* (9.2%), *C. fetus* (0.1%), *C. laridis* (0.2%), *C. upsaliensis* (0.9%), and *Campylobacter* species (6.8%) were also identified. Resistance profiles were as follows: 8.4% of the isolates (100/1195 tested) were resistant to ciprofloxacin, 57% (688/1207) to erythromycin, 9.1% (3/30) to norfloxacin, 29.1% (39/134) to tetracycline, and 2.8% (1/36) were resistant to chloramphenicol. The prevalence of ciprofloxacin resistance remained fairly constant over the study period, however erythromycin resistance increased substantially. Few age or gender associations with resistant infections were found. Submission rates and prevalence varied by health authority region.

Discussion: Further work is needed to identify the determinants of resistance in this population and investigate differences between jurisdictions. Linkages with *Campylobacter* agri-food data collected in SK through CIPARS will be explored.

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Appendix A – Methods

A.1 Categorization of Antimicrobial Drugs Based on Their Importance in Human Medicine

Categorization of antimicrobial drugs used in this report was taken from the Veterinary Drug Directorate's (VDD) Categorization of Antimicrobial Drugs Based on their Importance in Human Medicine[47]. Antimicrobials are considered of very High Importance in Human Medicine (Category I) as they meet the criteria of being essential for the treatment of serious bacterial infections and limited or no availability of alternative antimicrobials for effective treatment in case of emergence of resistance to these agents. 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 the 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 by Category II or I antimicrobials. Antimicrobials of Low Importance in Human Medicine (Category IV) currently not used in human medicine.

Table 29. Categorization of antimicrobial drugs based on their importance in human medicine.

Category of importance in human medicine	Antimicrobial Class
I Very High Importance	Carbapenems Cephalosporins – the third and fourth 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 – the first and second generations (including cephamycins) Fusidic acid Lincosamides Macrolides Penicillins Quinolones (except fluoroquinolones) Trimethoprim/sulfamethoxazole
III Medium Importance	Aminocyclitols Aminoglycosides (topical agents) Bacitracins Fosfomycin Nitrofurans Sulphonamides Tetracyclines Trimethoprim
IV Low Importance	Flavophospholipols Ionophores

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

A.2 Antimicrobial Resistance in Humans

Antimicrobial Resistance Sample and Data Collection

Hospital 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 (NNDRS) forwarding *Salmonella* cultures to the provincial reference laboratory is voluntary and passive in nature. The proportion of *Salmonella* isolates forwarded to the Provincial Public Health Laboratories (PPHLs) and Provincial Central Reference Laboratories is unknown and varies between laboratories.

In the past, PPHLs have forwarded a certain number of *Salmonella* isolates to the Enteric Diseases Program, National Microbiology Laboratory (NML), Winnipeg 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 between the NML, the Laboratory for Foodborne Zoonoses (LFZ), the Centre for Foodborne, Environmental Zoonotic Infectious Diseases (CFEZID), and the PPHLs. This signature officially launched the *Surveillance of Human Clinical Isolates* component of CIPARS.

The objective of this component is to implement and evaluate a prospective, representative, and methodologically unified approach to monitor temporal trends in the development of antimicrobial resistance in *Salmonella* from humans and to integrate this information with AMR information from the agri-food components. To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak and non-outbreak) received passively by PPHLs in New Brunswick, Newfoundland, Nova Scotia, Manitoba, Prince Edward Island, and Saskatchewan were forwarded to the NML. More populated provinces (Alberta, British Columbia, Ontario, and Québec) forwarded isolates they received from the first to the 15th of each month. However, all human *S.* Newport and *S.* Typhi were forwarded to the NML because of concerns of emerging multidrug resistance and clinical importance, respectively.

The PPHLs from each province were also asked to provide a defined set of information for each forwarded isolate including serovar, date collected, outbreak identification (if applicable), patient age, gender, and the province of residence. The provision of data on travel history, antimicrobial use, hospitalization status of the patient during specimen collection, and date of onset were optional and were not usually available to provide to the NML in 2006. Although many outbreaks are identified by PPHLs prior to isolate submission, some outbreaks are identified after the isolates have been forwarded to the NML.

Bacterial Isolation Methods

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

Serotyping and Phage Typing

The Identification and Serotyping, and Phage Typing units at the NML have attained 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 WHO GSS EQAS proficiency program for *Salmonella*, the EnterNet (European Surveillance Network) proficiency program for *Salmonella*, and a strain exchange with LFZ (*Salmonella* and *E. coli*). In addition, the NML has been a strategic planning member of WHO GSS since 2002.

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

Phage typing: All Salmonella Heidelberg, *S.* Typhimurium, *S.* Enteriditis, *S.* Hadar, S. Newport, *S.* Typhi, *S.* Paratyphi B, S. Paratyphi B var. L(+) tartrate+, *S.* Infantis, *S.* Thompson, S. Oranienburg, and *S.* Panama were phage typed at the NML. *Salmonella* isolates were maintained at room temperature until tested. For testing, isolates were plated on nutrient agar plates and incubated at 37°C for 18 hours. A single smooth colony was inoculated into 4.5 mL of Difco Phage Broth (DPB) (pH 6.8) and incubated for 1.5 to 2 hours in a shaking water bath at 37°C to attain a bacterial growth turbidity equivalent to 0.5 McFarland Standard. Difco Phage Agar (DPA) plates were flooded with

approximately 2 mL of culture and excess liquid was removed using a Pasteur pipette. Flooded plates were allowed to dry for 15 minutes at room temperature and approximately 20µl of each of the serovar specific typing phage were inoculated onto the bacterial lawn using a multiple inoculating syringe method (Farmer, Hickman and Sikes, 1956). The plates were incubated at 37°C overnight and lytic patterns were observed (Anderson and Williams, 1975).

Antimicrobial Susceptibility Testing Methods

See section A.3.

Data Analysis

See section A.3.

A.3 Antimicrobial Resistance in the Agri-Food Sector

Sampling Design and Data Collection

Abattoir Surveillance

The principal objective of CIPARS *Abattoir Surveillance* is to provide nationally representative and valid annual AMR data from bacteria isolated from animals entering the food chain. Initially, the program targeted generic *E. coli* and *Salmonella* from beef cattle, swine, and broiler chicken. Program refinement since 2002 has included the discontinuation of *Salmonella* isolation from beef cattle due to low prevalence. Further change in 2005 let to the inclusion of surveillance of beef cattle *Campylobacter* since late 2005. The unit of concern is the bacterial isolate. All isolates are tested for antimicrobial susceptibility with a panel of 15 antimicrobials for *E. coli* and *Salmonella*. The bacteria of interest are sampled from the caecal contents (not carcass) of slaughtered food-animals to avoid misinterpretation related to cross-contamination and to better reflect the antimicrobial resistance at the farm level.

The expected number of isolates to be yielded by the sampling is set at 150 per targeted bacterial species, for each of the three commodities, across Canada, over a 12-month period. The exception to this is *Campylobacter* in beef cattle where the expected number of isolates is set at 100.This number is a balance between acceptable statistical precision and affordability (Ravel, 2001). The actual number of specimens to be collected is derived for each commodity according to the expected caecal prevalence of the bacteria for this commodity, *e.g.* 1500 specimens have to be collected and submitted for bacterial isolation if the bacteria prevalence in the population is expected to be 10%.

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

Fifty-nine federally inspected slaughter plants (28 poultry plants, 18 swine plants, and 13 beef plants), from across Canada, participated in the 2006 CIPARS abattoir component. As stated above, the number of samples required for pork and chicken was based on the requirement for 150 *Salmonella* and 150 generic *E. coli* isolates per commodity and the expected prevalence of *Salmonella* and generic *E. coli* in each commodity. The sample size for beef was based on generating 100 *Campylobacter* and 150 generic *E. coli* isolates and the expected prevalence of *Campylobacter* and

E. coli in beef. Samples were taken according to a pre-determined protocol, with modifications to accommodate various line configurations in the different plants. Protocols were designed in order to avoid conflict with current inspection methodology, plant specific HACCP/Food Safety Enhancement Program, Health and Safety requirements, and industry's ability to salvage viscera. They were also designed to avoid situations of potential cross-contamination. The samples were collected by industry personnel under the oversight of the CFIA Veterinarian-in-Charge.

Retail Surveillance

Retail food represents a logical sampling node for AMR surveillance as it is the endpoint of the food pathway. The objective of CIPARS *Retail Surveillance* is to examine AMR among selected bacteria found in food at retail. This surveillance framework can be modified (e.g. food commodities, bacteria, regions) as necessary and function as a research platform to investigate specific questions regarding antimicrobial resistance in the agri-food sector.

The unit of concern is the bacterial isolate cultured from one of the commodities of interest and tested for susceptibility to a standard panel of 15 antimicrobials for *E. coli* and *Salmonella*, 9 antimicrobials for *Campylobacter*, and 17 antimicrobials for *Enterococcus*. The commodities of interest currently are raw meat products commonly consumed by Canadians and mirror those commodities sampled in CIPARS *Abattoir Surveillance*. They are poultry (chicken legs or wings [skin on]), pork (shoulder chops), and beef (ground beef). For ground beef in the first year of sampling (2003), only lean ground beef was selected, but in 2004 this was changed to a systematic selection of extra lean, lean, medium and regular ground beef to reflect the heterogeneity of this product in terms of the commodity combinations of fed beef and cull dairy, and the domestic vs. imported meat content. The meat cuts "legs or wings with skin on", "shoulder chops", and "ground beef" were also chosen based on high prevalence with regards to the targeted bacteria and its low cost of purchase (Ravel, 2002).

The bacteria of interest in poultry are *Campylobacter*, *Salmonella*, *Enterococcus*, and generic *E. coli*. In pork and beef only generic *E. coli* are cultured and further tested for AMR, given the low prevalence of *Campylobacter* and *Salmonella* at retail in these commodities as determined during the early phase of the program. *Salmonella* is isolated from pork but only to provide recovery estimates used by other PHAC programs for this commodity. Lastly, *Enterococcus* is not currently tested in beef and pork because of budgetary considerations.

The target population is Canadian consumers of retail meat. The sampling protocol mainly involves continuous weekly sample submissions from randomly selected census divisions, weighted by population, in each of the participating provinces. In 2006, retail surveillance data were collected in Saskatchewan, Ontario, and Québec. A short pilot AMR surveillance was also conducted in British Columbia. Using Statistics Canada data, between 15 and 18 census divisions were selected per province by stratified random selection. The strata were formed by the cumulative population quartiles from a list of divisions in a province sorted by population in ascending order and are summarized as follows:

In Ontario and Québec:
- Strata One - 10 divisions selected with two sampling days per division per year
- Strata Two - four divisions selected, with five sampling days per division per year
- Strata Three - two divisions selected with 10 sampling days per division per year
- Strata Four - one division, 20 sampling days per year

In Saskatchewan:
- Strata One - nine divisions selected with two sampling days per division per year
- Strata Two - five divisions selected, with three sampling days per division per year
- Strata Three - two divisions selected with five sampling days per division per year
- Strata Four - one division, seven sampling days per year

Field workers in Ontario and Québec conduct one sampling day per week and in Saskatchewan one sampling day every other week. Sampling is currently less frequent in Saskatchewan due to present funding constraints, limited laboratory capacity and to avoid store related over-sampling. Samples are collected on Monday or Tuesday for submission to the LFZ, Saint-Hyacinthe, Québec by Wednesday. Samples submitted from outside Québec are sent via 24-hour courier. In each province, two census divisions are sampled on each sampling day. In each census division, a slate of four stores is selected prior to the sampling day based on *Store Type*. Generally, three chain stores and one independent market or butcher shop are selected for sampling. An exception to this protocol is made

in densely populated urban divisions, *e.g.* Toronto and Montreal, where two chain stores and two independent markets or butcher shops are sampled to reflect the shopping behaviour of that sub-population. From each *Store Type* one sample of each commodity of interest is collected, providing 11 meat samples per division per sampling day. At one store in each division, one beef sample is dropped in order to minimize over-sampling of this commodity. If possible, specific store locations are to be sampled only once per sampling year. Using prevalence estimates, sampling protocols are optimized to yield 100 isolates per commodity per province per year (anticipated), plus 20% for lost or damaged samples.

In 2006, Personal Digital Assistants (PDAs) were used to capture the following store and sample data:
- Type of store
- Number of cash registers – a surrogate measure of store volume
- Sell-by or packaging date
- Product Origin: Canada / USA / Other
- Federal Inspection stamp: YES/NO (Y/N)
- "May Contain Previously Frozen Meat" label: Y/N
- Final Processing in store: Y/N
- Price/kg

Individual samples were packaged in sealed 'zipper' type bags and placed in 16 litre thermal coolers for transport. The ambient environmental temperature determined the number of ice packs placed in each cooler (e.g. one ice pack for temperatures below 20°C and two ice packs for temperatures 20°C or above). Temperature data recording instruments (Ertco Data Logger, West Patterson, NJ, USA) were used to monitor the temperature experience of samples in one or two coolers per sampling day.

Surveillance of Animal Clinical Isolates

Surveillance of Animal Clinical Isolates component originate primarily from veterinary diagnostic submissions collected by veterinarians and/or producers. Since the samples were submitted for diagnostic purposes, private veterinarian practitioners and/or producers collect the samples. Therefore, the sample collection methodology varied both between and within laboratories. These isolates are sent by provincial animal health laboratories across the country to the Salmonella Typing Laboratory at the Laboratory for Foodborne Zoonoses (Guelph, Ontario). However, unlike our *Surveillance of Human Clinical Isolates* program, all isolates received by provincial animal health laboratories may not necessarily be forwarded to the LFZ, with the exception of the provinces of Ontario and Québec. Coverage may therefore vary considerably between provinces.

On-Farm Surveillance

The *On-farm Surveillance* is the most recent component of CIPARS and complements existing abattoir and retail sampling activities. The On-Farm component is largely supported by the 5 year (2003 to 2008) Agricultural Policy Framework (APF) agreement between Agriculture and Agri-Food Canada and various partners including Health Canada and the Public Health Agency of Canada. This initiative focuses on a sentinel farm framework providing data on antimicrobial use and on-farm samples for bacterial isolation and antimicrobial susceptibility testing and is administered and co-ordinated by the Laboratory for Foodborne Zoonoses, Public Health Agency of Canada.

In 2006, the CIPARS *On-farm Surveillance* component was implemented in swine herds across the five major pork producing provinces in Canada. The swine industry was selected as the pilot commodity for surveillance infrastructure development because there is extensive implementation of the Canadian Quality Assurance (CQA®) program by the industry, there was the absence of a recent foreign animal disease outbreak and there was a similar initiative in swine in the United States (Collaboration in Animal Health and Food Safety Epidemiology).

The objectives of the CIPARS On-farm surveillance program are:
- To establish the infrastructure to support a national surveillance program.
- To provide data on antimicrobial use and resistance.
- To investigate associations between antimicrobial use and resistance.
- To provide data for human health risk assessments.

The surveillance program focuses on grower-finisher hogs. Grower-finisher hogs are the focus because of their proximity to the consumer and the need to gain a better understanding of the impact of on-farm antimicrobial use and antimicrobial resistance on public health. Expansion of this surveillance program to include additional stages of production would be considered if funding becomes available.

Nationally, 29 veterinarians and 108 sentinel grower-finisher sites are enrolled. In each of the 5 participating provinces, the number of CIPARS sentinel sites is proportional to the national total of grower-finisher units, except in Alberta and Saskatchewan where 10 additional cohort herds were included. This was made possible through financial and laboratory support provided by Agriculture and Food, Alberta, and Saskatchewan Agriculture and Food. Agriculture and Food, Alberta, also provided laboratory support for the CIPARS funded herds in that province.

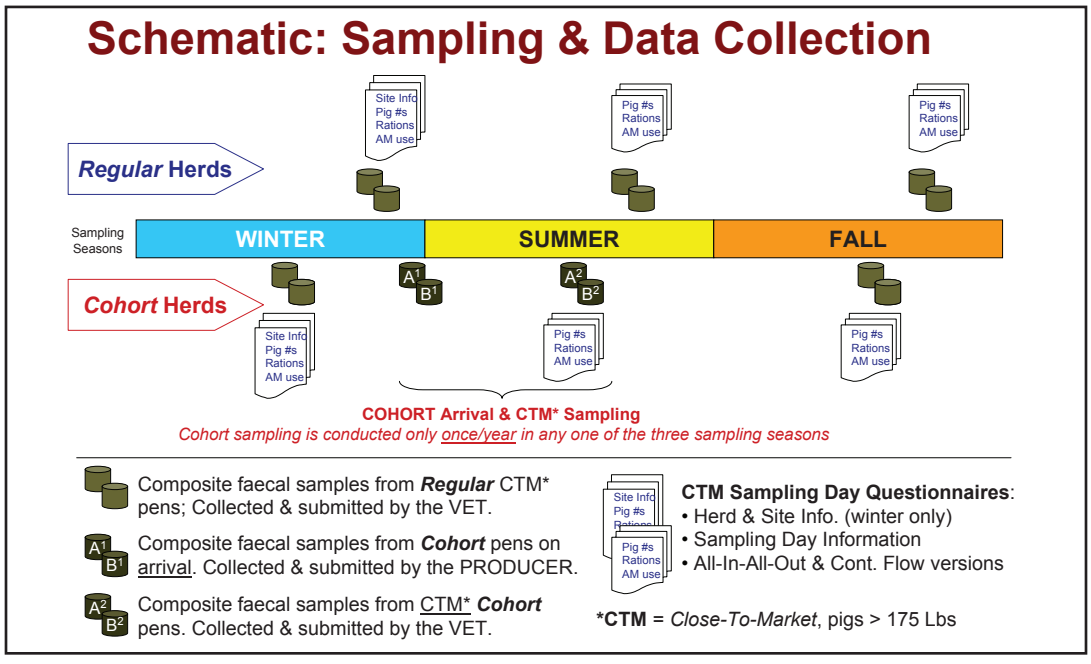
To provide producer anonymity, herd veterinarians conducted the sample and data collection and submitted depersonalized information to PHAC. In the case of corporate herds, 2 private supervisory veterinarians ensured confidentiality by holding the key to corporate herd codes. This step was taken because knowing a corporate veterinarians name could identify the corporation associated with the herd thereby preventing anonymity.

Veterinarians were purposively selected from provincial sampling frames. Using specified inclusion/exclusion criteria, each veterinarian selected a set number of sentinel farm sites. The criteria for inclusion were; herds had to be CQA® validated, herds had to produce more than 2000 market hogs per year and herds had to be representative of the demographic (e.g. corporate, independent, co-operative/loops, production volume) and geographic distribution of herds in the contractor's swine practice. Criteria for exclusion were; herds that were regarded to be organic pertaining to animal husbandry, herds that were feeding edible residual material or herds that were raised on pasture. The inclusion/exclusion criteria helped ensure that the herds enrolled were representative of the majority of hog production in Canada.

Pooled fecal samples were collected from pens of close-to-market weight finisher hogs 3 times annually (Figure 43). In a subset of herds, specific cohorts of pigs were followed. Cohort pens had pooled fecal samples collected at arrival and again when close to market. Close-to-market hogs were defined as hogs weighing > 175 Lbs and cohort arrival samples were collected within 6 hours of the hogs entering the grow finisher unit.

All fecal samples were cultured for generic *E. coli*, *Enterococcus*, and *Salmonella* using the standard CIPARS methodology. Susceptibility testing was performed on 5 *E. coli* isolates, and 3 *Enterococcus* spp. isolates. If cultured, 1 *Salmonella* spp. isolate per sample was also tested.

Figure 43. Example of sampling visits in regular and cohort herds over a calendar year.



Bacterial Isolation Methods

Abattoir, Retail, and On Farm Surveillance

Primary isolation of *E. coli, Salmonella, Enterococcus* spp., and *Campylobacter* spp., and antimicrobial susceptibility testing of *E. coli, Enterococcus* spp., and *Campylobacter* spp. were conducted at LFZ, Saint-Hyacinthe, Québec. *Salmonella* isolates were sent to the LFZ, Guelph, Ontario for testing as follows: serotyping and phage typing were performed by the *Salmonella* Typing Laboratory (STL) and antimicrobial susceptibility testing was performed by the CIPARS Guelph Laboratory. The LFZ Guelph laboratory is ISO/IEC 17025 accredited by the Standards Council of Canada. The STL is also designated as an OIÉ Reference Laboratory for salmonellosis. STL is a member of the WHO Global *Salmonella* Surveillance network (GSS) since 2000. STL is listed on the GSS web page and provides yearly *Salmonella* summary data[48]. The STL participates in a yearly External Quality Assurance System for *Salmonella* serotyping (EQAS) among GSS member labs, as well as yearly inter-laboratory exchange programs with the Ontario Ministry of Health, Toronto (Ontario) and NML, Winnipeg (Manitoba). In 2003, STL began external proficiency testing for phage typing and successfully completed a phage typing proficiency panel provided by NML originating from the Central Public Health Laboratory, Colindale (England). Both LFZ-Guelph and LFZ Saint-Hyacinthe currently participate in external proficiency AMR testing for *Salmonella, E. coli* and *Enterococcus*.

Abattoir Surveillance

Salmonella The method used 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 allows isolation of motile and viable *Salmonella* from caecal content of broiler and swine samples. The method was based on the capacity of *Salmonella* to multiply and be motile in Modified Semi-Solid Rappaport Vassiliadis (MSRV) media at a temperature of 42°C. Porcine samples were added to a non-selective pre-enrichment broth; 10 g of caecal contents were mixed with 90 mL of buffered peptone water (BPW). In the same manner, avian caecal contents were weighed and BPW was added in a proportion of 1:10. The porcine and avian samples were incubated at 35°C for 24 hours. Then a MSRV plate was inoculated with 0.1 ml of the pre-enrichment broth and was incubated at 42°C for 24 to 72 hours. Suspect colonies were screened for purity and inoculated on Triple Sugar Iron (TSI) and urea agar slants. Presumptive *Salmonella* isolates were then submitted to the indole test and were verified by slide agglutination using Poly A-I and Vi *Salmonella* antiserum.

Escherichia coli This bacteria has been isolated from the caecal contents of broilers, swine and beef cattle samples. A drop of BPW aliquot prepared for the *Salmonella* isolation was inoculated on a MacConkey (MAC) agar and incubated at 35°C for 18 to 24 hours. Suspect lactose fermenting colonies were screened for purity and transferred onto Luria-Bertani (LB) agar. Presumptive colonies were identified using citrate and indole test. Colonies showing negative indole results were identified using the API 20E (bioMérieux Clinical Diagnostics, Marcy l'Étoile, France).

Campylobacter Two methods were used for the isolation of *Campylobacter* in beef cattle caecal content. In the first method, 0.1 ml of pre-enrichment broth prepared for the *Salmonella* isolation were streaked on a modified cefoperazone charcoal deoxycholate agar (mCCDA) and incubated in a microaerophilic atmosphere at 42°C for 24 hours. Suspect colonies were streaked on another mCCDA plate for purity and on Mueller Hinton Agar supplemented with 5% sheep blood (MHB). The plates were incubated in a microaerophilic atmosphere at 42°C for 48 to 72 hours. The following tests were performed on presumptive colonies: Gram stain, oxidase, catalase, growth at 25°C, cephalothin resistance, hippurate and indoxyl acetate hydrolysis. In the second method, 1 g of beef cattle caecal content was mixed with 9 ml of double strength Bolton Broth and incubated in a microaerophilic atmosphere at 42°C for 48 hours. The incubated broth was then streaked on mCCDA and incubated in a microaerophilic atmosphere at 42°C for 24 hours. The next steps used in the second method are the same as those used in the first one.

Retail Surveillance

Salmonella Two methods were used for the isolation of *Salmonella* in chicken. In the first method, chicken leg or wings were added to 225mL of BPW. Fifty ml of this peptone rinse were incubated at 35°C for 24 hours. In the second method, chicken leg or wing samples were left in the remaining BPW rinse and were incubated at 35°C for 24

[48] http://www.who.int/salmsurv/en

hours. Then two MSRV plates were inoculated with 0.1 ml of the two incubated BPW rinse. Plates were incubated at 42ºC for 24 to 72 hours. Suspect colonies were screened for purity and inoculated on TSI and urea agar slants. Presumptive *Salmonella* isolates were then submitted to the indole test and were verified by slide agglutination using Poly A-I and Vi *Salmonella* antiserum.

Escherichia coli Chicken leg or wings, pork chop and 25 g of ground beef were added to 225 ml of BPW. Fifty ml of this peptone rinse were mixed with 50 mL of double strength EC Broth and incubated at 45°C for 24 hours. A loopful from the incubated mix was streaked on Eosin Methylene Blue (EMB) Agar and incubated at 35°C for 24 hours. Suspect colonies were screened for purity and transferred onto Trypticase Soy Agar with 5% sheep blood (TSA-B). Presumptive colonies were identified using the Simmons citrate and indole tests. Colonies showing negative indole results were identified using the API 20E (bioMérieux Clinical Diagnostics, Marcy l'Étoile, France).

Campylobacter Chicken leg or wings were mixed with 225 ml of BPW. Fifty ml of this 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 on a mCCDA plate and incubated in a microaerophilic atmosphere at 42°C for 24 hours. Suspect colonies were streaked on another mCCDA plate and on Mueller Hinton Agar supplemented with 5% sheep blood (MHB). The plates were incubated in a microaerophilic atmosphere at 42°C for 48 to 72 hours. The following tests were performed on presumptive colonies: Gram stain, oxidase, catalase, growth at 25°C, cephalothin resistance, hippurate, and indoxyl acetate hydrolysis.

Enterococcus Chicken leg or wings were added to 225 ml of BPW. Fifty ml of this peptone rinse were mixed with 50 ml of double strength Enterococcosel Broth and incubated at 35°C for 24 hours. A loopful from the incubated broth was then streaked on an Enterococcosel Agar and incubated at 35°C for 24 hours. Suspect colonies were screened for purity on Columbia Agar with 5% sheep blood (CBA). Presumptive colonies were transferred on Slaneth and Bartley Agar and inoculated in three tubes of Phenol Red Base Broth containing 0.25% *L*-arabinose, 1% mannitol and 1% alpha-methyl-*D*-glucoside respectively. The plate and tubes were incubated at 35° for 24 hours.

On Farm Surveillance

All fecal swine samples were cultured for generic *E. coli*, *Enterococcus*, and *Salmonella* using the standard CIPARS methodology. Susceptibility testing was performed on 5 *E. coli* isolates, and 3 *Enterococcus*. isolates, and 1 *Salmonella* isolate per sample.

Salmonella Ten grams of feces were mixed with 90 ml of BPW and incubated at 35° for 24 hours. Further description of bacterial isolation methods are described in the CIPARS *Abattoir Surveillance* section.

Escherichia coli A drop of BPW aliquot prepared for the *Salmonella* isolation was inoculated on a McConkey agar and incubated at 35° for 18 to 24 hours. Further description of bacterial isolation methods are described in the CIPARS *Abattoir Surveillance* section.

Enterococcus A drop of the incubated BPW aliquot prepared for the *Salmonella* isolation was inoculated on an Enterococcosel Agar and incubated at 35° for 24 hours. Further description of bacterial isolation methods are described in the CIPARS Retail Surveillance section.

Surveillance of Animal Clinical Isolates

Submitting laboratories isolated *Salmonella* according to their standard procedures, which varied from one laboratory to another. Most methods for examining products for the presence of *Salmonella* are similar in principle and involve pre-enrichment, selective enrichment, differential and selective plating, isolation, and biochemical and serological confirmation of the selected isolates.

Serotyping, Phage Typing, and Antimicrobial Susceptibility Testing Methods

Serotyping

The O or somatic antigens of the *Salmonella* isolates were determined by slide agglutination (Ewing, 1986). The H or flagellar antigens were identified using a microtechnique (Shipp and Rowe, 1980) that employs microtitre plates. The antigenic formulae of Le Minor and Popoff (2001) were used to name the serovars. *Salmonella* of human origin were tested by the NML-Winnipeg, Manitoba, while isolates from agri-food samples were processed at the LFZ-Guelph, Ontario, and at the Laboratoire d'épidémiosurveillance animale du Québec (Québec isolates).

Phage Typing

The standard phage typing technique described by Anderson and Williams (1956) was followed. *Salmonella* Enteritidis strains were phage typed with typing phages obtained from the International Centre for Enteric Phage Typing (ICEPT), Central Public Health Laboratory, Colindale, United Kingdom (Ward, *et al.*, 1987) via NML, Winnipeg, Manitoba. The phage typing scheme and phages for *Salmonella* Typhimurium, developed by Callow (1959) and further extended by Anderson (1964) and Anderson and colleagues (1977), were obtained from the ICEPT via NML. The *Salmonella* Heidelberg phage typing scheme and phages were supplied by NML (Demczuk *et al.*, 2003). Isolates that reacted with the phages but did not conform to any recognized phage type were designated as atypical (AT). Strains which did not react with any of the typing phages were designated as untypable (UT). *Salmonella* of human origin were tested by the NML, while most isolates from agri-food samples were processed at the LFZ-Guelph, Ontario. All *S.* Newport of human and agri-food origin were phage typed at the NML-Winnipeg, Manitoba.

Antimicrobial Susceptibility Testing

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

***Salmonella*, *E. coli*, and *Enterococcus*.** MIC values for *Salmonella*, *E. coli*, and *Enterococcus* were determined by the broth microdilution method (NCCLS/CLSI - M7-A7). This method was performed using the Sensititre™ Automated Microbiology System (Trek™ Diagnostic Systems Ltd). Sensititre™ is a commercially available broth dilution technique using dehydrated antimicrobials in the wells of microtitre plates. NARMS susceptibility panels CMV1AGNF (Sensititre™) were used for *E. coli* and *Salmonella* while the CMV1AGPF (all retail and part of on-farm) and CMV2AGPF (on-farm in Alberta and Saskatchewan) plates were used for *Enterococci*. The specimens were streaked onto a Mueller Hinton Agar (or Columbia Blood Agar or Mueller Hinton Blood Agar) plate to obtain isolated single colonies and incubated inverted at 37°C (NML-Winnipeg) or 35° (LFZ-Guelph, LFZ-Saint-Hyacinthe) for 18 to 24 hours. A single colony is chosen from this plate, re-streaked onto agar plates for growth, and incubated at 37°C (NML-Winnipeg) or 35° (LFZ-Guelph, LFZ-Saint-Hyacinthe) for 18 to 24 hours. A 0.5 McFarland suspension of bacterial growth was prepared by transferring colonies to 5.0 ml sterile demineralized water and suspended by vortexing the tube. A volume of 10 µl of the water-bacterial suspension was transferred to 10 ml Mueller-Hinton broth and mixed by using a vortex mixer. The Mueller Hinton broth suspension was dispensed into plates at a rate of 50 µl per well. The plates were sealed with adhesive plastic sheets and incubated for 18 hours at 37 °C (LNM, Winnipeg) and at 35° (LFZ, Guelph and Saint-Hyacinthe). Detection of possible vancomycin-resistant *Enterococci* required 6 more hours of incubation for a total of 24 hours. After incubation, the CMV1AGNF plates were read and interpreted using the ARIS system whereas the CMV1AGPFand CMV2AGPF plates were manually read using the Sensititre Sensitouch™ apparatus. *Staphylococcus* aureus ATCC 29213, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Enterococcus faecalis* ATCC 29212 were used for quality assurance purposes to ensure validity and integrity of the MIC values of the susceptibility CMV1AGNF panels as outlined by the CLSI (NCCLS/CLSI - M100-S16). *Staphylococcus aureus* ATCC 29213, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, and *Enterococcus faecalis* ATCC 51299 were used as quality controls for *Enterococcus* susceptibility testing.

***Campylobacter*.** MIC values for *Campylobacter* were determined by the broth microdilution method (NCCLS/CLSI-M7-A7). Antimicrobial susceptibility testing was performed using NARMS susceptibility panels CAMPY (Sensititre™). The colonies were streaked on 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

colonies to 5 ml of Mueller Hinton broth (MHB) and suspended using a vortex mixer for at least 10 seconds. 10 µl of the MHB was then transferred in 11 ml of MHB with laked horse blood (LHB) and mixed for 10 seconds. The MHB-LHB mix was dispensed into plates at a rate of 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. MIC values were compared to CLSI standards (NCCLS/CLSI – M45-A).

A.4 Data Analysis, Validation, and Review

Susceptibility data from *Surveillance of Human Clinical Isolates* were provided by NML (Winnipeg, Manitoba). Susceptibility data from all animal *Salmonella* isolates (*Surveillance of Animal Clinical Isolates, Abattoir Surveillance, and Retail Surveillance*) were provided by LFZ (Guelph, Ontario). Susceptibility data on *E. coli*, *Campylobacter*, and *Enterococcus* isolates, and all recovery data from *Abattoir, Retail* and *On-Farm Surveillance* were obtained from LFZ (Saint-Hyacinthe, Québec), except all data from Alberta and Saskatchewan for *On-Farm Surveillance* which came from provincial laboratories from these provinces . All initial datasets were checked for data validity. All submissions from outside the country were excluded from analysis.

Human, Abattoir, Retail, and Animal Clinical Data Analysis

Data were analyzed using SAS™ V 9.1 (SAS Institute Inc., Cary, NC, USA), Stata 8 (Stata Corp., College Station, TX, USA), and Excel notebook software (Excel 2000, Microsoft Corp., Redmond, WA, USA). All figures were generated with Microsoft® Excel 2000. Exact confidence intervals were computed using SAS BINOMIAL statement in PROC FREQ and an alpha level of 0.05. When prevalence was zero, an alpha level of 0.1 was used.

The Individual Antimicrobial Drug Resistance percentage was the number of isolates resistant divided by the total number of isolates tested for each individual antimicrobial. The breakpoints used for the interpretation of susceptibility results are listed in Table 30, Table 31, and Table 32.

The Number of Antimicrobials in Resistance Pattern was calculated by adding the number of resistant results across all antimicrobials tested for each isolate.

For the *Abattoir Surveillance* and *Retail Meat Surveillance* components, the 'recovery rate' was the number of samples where the target bacterial organism was detected divided by the total number of samples processed.

For the human incidence data, the number of cases per 100,000 inhabitant-year in each province was calculated by dividing the total number of cases received by CIPARS in each province by that province population (Stat. Can. Post-censal population estimates Jan, 1, 2005), multiplied by 100 000. The national estimates for all serovars except *S.* Typhi and *S.* Newport were calculated as followed: in provinces submitting isolate during the first 15 days of the month, the number of resistant isolates and the total number of submitted isolates were multiplied by two each month; the number of resistant isolates (estimated in larger province or actual number in smaller provinces) were added; the total number of isolates submitted (estimated in larger province or actual numbers in smaller provinces) were added; the total estimated number of resistant isolates was divided by the total estimated number of submissions for each antimicrobial tested to obtain a national estimate of resistance for each antimicrobial and each serovar.

Temporal analyses were performed on a selected list of antimicrobials. As much as possible, only one antimicrobial per antimicrobial class was selected among those antimicrobials frequently used in the agri-food and/or human sectors. Some antimicrobials were excluded from the temporal analyses for the following reasons:

- The antimicrobial presented a low prevalence of resistance and other antimicrobials could be used to provide a surrogate measure of resistance or intermediate susceptibility (e.g. nalidixic acid for ciprofloxacin, ceftiofur for ceftriaxone).
- The antimicrobial was exhibiting cross resistance with another antimicrobial selected (ex.: amoxicillin-clavulanic acid and ceftiofur).
- The antimicrobial is not frequently used by the agri-food or the human sector or 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 fitted with year as an independent categorical variable. The data were manipulated using Versions 9.1 of the statistical package STATA (STATA Corp., College Station, Texas, USA) or R version 2.2.1. Firth's penalized maximum likelihood (PML) was performed (with R version 2.2.1) when data separation (one or more zero cells in the contingency table) was encountered. In most cases, the 2003 year was selected as the baseline period thus a comparison between the years 2003-2006 was performed (significant if alpha ≤ 0.05). Comparisons between 2004 and 2006 were also made for resistance to ampicillin and ceftiofur in chicken *E. coli* and *Salmonella* in order to assess changes in resistance after the early 2005 voluntary ceftiofur withdrawal by Québec chicken hatcheries.

On-Farm Data Analysis

For the On-farm analysis, the same statistical methods were used to analyze the antimicrobial resistance of each bacterial species unless specifically noted. The bacterial species, serovar, and minimum inhibitory concentration (MIC) data were maintained in a relational database (Microsoft Access; Microsoft Corporation, Redmond, Washington, USA). Intermediate MIC values were categorized as susceptible for all analyses.

Descriptive analyses were conducted using commercially available software (Microsoft Excel 2003; Microsoft Corporation, Redmond, Washington, USA). All statistical analyses accounted for clustering of resistance within herds through generalized estimating equations (GEE) (PROC GENMOD, SAS for Windows version 9.1; SAS Institute, Cary, North Carolina, USA). All models had a binary outcome, logit-link function, and an exchangeable correlation structure.

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

Not every *Enterococci* isolate was tested for resistance to each antimicrobial. Susceptibility testing was conducted in three labs; two of which had the same MIC panel and one of which had a different panel. *Enterococci* tested by PHAC were tested for susceptibility to bacitracin but not to tigecycline. In contrast, *Enterococci* tested by Prairie Diagnostic Services (PDS) and Alberta Agriculture were tested for susceptibility to tigecycline but not to bacitracin. *E. faecalis* is considered intrinsically resistant to lincomycin and quinupristin-dalfopristin. Therefore, isolates of these species were excluded from those analyses.

Table 30. *Salmonella* and *E. coli* breakpoints in 2006 (CMV1AGNF plate).

	Antimicrobial	Range tested in 2006 μg/ml	Breakpoints [1] 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[2]	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					

Note: Categorization of Antimicrobial Drugs Based on Importance in Human Medicine (I to IV).

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

[2] No CLSI Enterobacteriaceae interpretive criteria available for this antimicrobial. Breakpoints based on MIC distribution and harmonized with NARMS.

Table 31. *Campylobacter* breakpoints in 2006 (*Campylobacter* plate).

	Antimicrobial	Range tested in 2006 μg/ml	Breakpoints [1] μg/ml		
			S	I	R
I	ciprofloxacin	0.015-64	≤ 1	2	≥4
	telithromycin [2]	0.015-8	≤ 4	8	≥ 16
II	azithromycin [2]	0.015-64	≤ 2	4	≥ 8
	clindamycin [2]	0.03-16	≤ 2	4	≥ 8
	erythromycin	0.03-64	≤ 8	16	≥ 32
	gentamicin [2]	0.12-32	≤ 2	4	≥ 8
	nalidixic acid [2]	4-64	≤ 16	32	≥ 64
III	florfenicol [2,3]	0.03-64	≤ 4	-	-
	tetracycline	0.06-64	≤ 4	8	≥ 16
IV					

Note: Categorization of Antimicrobial Drugs Based on Importance in Human Medicine (I to IV).

[1] CLSI M45.

[2] No CLSI *Campylobacter* interpretive criteria available for this antimicrobial. Breakpoints based on MIC distribution and harmonized with NARMS.

[3] No resistance breakpoint defined to this point.

Table 32. *Enterococcus* breakpoints in 2006 (CMV1AGPF and CMV2AGPF plate).

	Antimicrobial	Range tested in 2006 μg/ml	Breakpoints [1] μg/ml		
			S	I	R
I	ciprofloxacin	0.12-4	≤ 1	2	≥ 4
	daptomycin[2] (cyclic lipopeptide)	0.5-16	≤ 4	-	-
	linezolid (oxazolidinones)	0.5-8	≤ 2	4	≥ 8
	quinupristin-dalfopristin (streptogramins)	1-32	≤ 1	2	≥ 4
	tigecycline[3]	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)	128-1024	≤ 500	-	> 500
	kanamycin[1](high-level)[2]	128-1024	≤ 128	256	≥512
	lincomycin[2]	1-32	≤ 8	16	≥ 32
	penicillin	0.5-16	≤ 8	-	≥ 16
	streptomycin (high-level)[2]	512-2048	≤ 1,000	-	> 1,000
	tylosin[2]	0.25-32	≤ 16	-	≥ 32
III	bacitracin	8-128	≤ 32	64	≥ 128
	chloramphenicol	2-32	≤ 8	16	≥ 32
	nitrofurantoin	2-64	≤ 32	64	≥ 128
	tetracycline	4-32	≤ 4	8	≥ 16
IV	flavomycin[2]	1-16	≤ 8	16	≥ 32

Note: Categorization of Antimicrobial Drugs Based on Importance in Human Medicine (I to IV).

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

[2] No CLSI Enterococcus interpretive criteria available for this antimicrobial. Breakpoints based on MIC distribution and harmonized with NARMS.

[3] *On-Farm Surveillance:* tigecycline was tested only on isolates from Alberta and Saskatchewan.

A. 5 Human Antimicrobial Use Data Collection and Analysis

CompuScript

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

The sampling frame (or "universe") for this dataset did not change from that presented in the 2005 CIPARS report, which consisted of approximately 7,571 pharmacies, which includes approximately 5,981 chain stores (2,491 large and 3,490 small) and approximately 1,590 independent stores (225 large and 1,365 small), which covers nearly all the retail pharmacies in Canada. IMS Health stratifies the "universe" by store size (based on purchase volumes), type (chain or independent), and region (10 provinces).

The sample design requires approximately 1,431 stores; however, IMS Health utilizes more stores because they have a large sample base. An average of 2,765 pharmacies was used over 12 months to create the estimates for 2005. From this sample, IMS Health calculates a projection factor by dividing the number of stores in the "universe" by the number of stores in the sample. The projection factor is used to extrapolate the number of prescriptions dispensed in the sample to that of the "universe" (7,571 pharmacies).

Drugs were classified and Defined Daily Doses (DDDs) were determined according to the Anatomical Therapeutic Chemical (ATC) classification system[49] (Table 33). Temporary DDDs (not yet approved but posted on WHO site) were used when available. For pediazole, the DDDs for erythromycin ethyl succinate (2 g) was used. For oral presentation of penicillin g, the DDD for benzilpenicillin by parenteral route (3.6) was used. Drugs with no DDDs were also excluded, which included trisulfaminic (drug discontinued in 2001, total of 832384 extended units in 2000 only).

Although no hospital pharmacies are included in the CCS sample, CCS data includes a small volume of antimicrobials delivered in non-oral forms such as injectable drugs or products administered by inhalation. Inconsistencies related to non-oral drugs, which represent a very small volume of the CCS data, were judged too frequent to include in this analysis. Consequently, the 2006 report only describes drugs delivered by oral forms from retail pharmacies. Only drugs of the J01 ATC group were kept in analysis. Oral vancomycin (ATC group A07AA) was kept in the sample and was included under class J01XA.

The total amount of active ingredient was obtained by multiplying the number of extended unit (real or corrected) by the strength of the product in grams. In the case of combo drugs, the active ingredient of all antimicrobial components of the combo drugs were added to get the total number of active ingredient. However, the amount of active ingredient used in the calculation of the total number of DDDs in the case of combo drugs only included the molecule from which the DDDs was derived. For example, in the case of drugs composed of sulfamethoxazole-trimethoprim, 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 this given year (365 or 366). The total number of prescription and total cost per 1,000 inhabitants was obtained by dividing the total number of prescription or the total cost by the population size in thousands for each year. Population data were from updated and preliminary postcensal estimates, based on the 2001. Census counts adjusted for net undercoverage (Statistics Canada).

In 2002 and 2003 CIPARS reports, methenamine and linezolid were classified under “Other antimicrobials”; as of 2004 they have been reported separately to harmonise with reports from other surveillance programs such as DANMAP. 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. Information is therefore missing in the tables and this amount was not included in any totals for year 2000.

[49] WHO Collaborating Centre for Drug Statistics Methodology: http://www.whocc.no/atcddd/.

Table 33. List of antimicrobial drugs from the IMS database for each ATC class.

	ATC Class		Antimicrobial
I	J01CR	combinations of penicillins, incl. 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
	J01XX08	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, incl. derivatives	sulfadiazine-trimethoprim, sulfamethoxazole-trimethoprim
	J01FA	macrolides	azithromycin, clarithromycin, erythromycin, spiramycin, telithromycin
	J01FF	lincosamides	clindamycin, lincomycin
	J01GB	aminoglycosides	neomycin
	J01MB	other quinolones	nalidixic acid
	J01RA	sulfonamide combinations (excl. trimethoprim)	erythromycin sulfisoxazole
	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	J01XX05	methenamine	methenamine, methenamine-sodium-tartaric acid

Note: Roman numerals I-III indicate the categorization of antimicrobials based on their importance in human medicine as outlined by the Veterinary Drugs Directorate. NC: Not classified.

Appendix B – Additional Tables

B.1 Antimicrobial Resistance in Humans

Table 34. Details regarding the age and province distribution of human *Salmonella* isolates; *Surveillance of Human Clinical Isolates*, 2006.

Age distribution n/N (%)	Province n/N (%)
Less than 5 years: 429/3205 (13%)	Alberta: 368/3205 (11%)
5 to 12 years: 321/3205 (10%)	British Columbia: 394/3205 (12%)
13 to 17 years: 149/3205 (5%)	Manitoba: 155/3205 (5%)
18 to 29 years: 577/3205 (18%)	New Brunswick: 180/3205 (6%)
30 to 49 years: 698/3205 (22%)	Newfoundland and Labrador: 27/3205 (1%)
50 to 69 years: 526/3205 (16%)	Nova Scotia: 85/3205 (3%)
70+ years: 231/3205 (7%)	Ontario: 1356/3205 (42%)
NA: 274/3205 (9%)	Prince Edward Island: 30/3205 (1%)
	Québec: 477/3205 (15%)
	Saskatchewan: 132/3205 (4%)
	Nunavut: 1/3205 (<1%)

Note: NA=Not available.

Table 35. Details regarding specimen source of the primary human *Salmonella* serovars; *Surveillance of Human Clinical Isolates*, 2006.

Specimen source	Enteritidis N=710 n (%)	Heidelberg N=430 n (%)	Newport N=146 n (%)	Paratyphi A and B N=66 n (%)	Typhi N=164 n (%)	Typhimurium N=539 n (%)	Other serovars N=1150 n (%)	Total N=3205 n (%)
Stool	542 (76)	306 (71)	96 (66)	9 (14)	35 (21)	406 (75)	805 (70)	2199 (69)
Blood	19 (3)	34 (8)	5 (3)	34 (52)	80 (49)	9 (2)	33 (3)	214 (7)
Urine	13 (2)	16 (4)	11(8)			9 (2)	54 (5)	103 (3)
Anatomy							1 (<1)	1 (<1)
Abscess					2 (1)	1 (<1)		3 (<1)
Fluid							1 (<1)	1 (<1)
Sputum							1 (<1)	1 (<1)
Unknown	136 (19)	74 (17)	34 (23)	23 (35)	47 (29)	114 (77)	255 (22)	683 (21)

Table 36. Distribution of MICs and resistance in *Salmonella* Enteritidis recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	710	<=1	<=1	0.1							93.8	3.0	0.7	2.3	0.1		**0.1**			
	ceftiofur	710	1	1	0.3						9.9	88.3	1.3	0.3		**0.3**					
	ceftriaxone	710	<=0.25	<=0.25	0.0					99.3	0.3		0.3				0.1				
	ciprofloxacin	710	<=0.015	0.12	0.0	74.5	5.1	0.3	11.7	7.6	0.8										
II	amikacin	710	1	1	0.0						34.9	60.8	3.8	0.4							
	ampicillin	710	<=1	2	3.0							80.8	15.2	0.8		0.1	**0.1**	**2.8**			
	cefoxitin	710	2	2	0.1							5.4	88.7	4.6	1.0	0.1		**0.1**			
	gentamicin	710	<=0.25	<=0.25	0.0					91.0	8.3	0.4	0.1		0.1						
	kanamycin	710	<=8	<=8	0.3										99.7				**0.3**		
	nalidixic acid	710	4	>32	20.1								18.3	60.4	0.7	0.4	**0.6**	**19.6**			
	streptomycin	710	<=32	<=32	1.4												98.6	**0.6**	**0.8**		
	trimethoprim-sulphamethoxazole	710	<=0.12	<=0.12	0.6				90.1	9.2	0.1			**0.3**	**0.3**						
III	chloramphenicol	710	4	8	0.3								0.1	62.1	36.9	0.6	**0.1**	**0.1**			
	sulfisoxazole	710	64	64	1.3											1.0	42.4	54.5	0.7	0.1	**1.3**
	tetracycline	710	<=4	<=4	3.5									95.6	0.8	**0.6**	**0.7**	**2.3**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 37. Distribution of MICs and resistance in *Salmonella* Heidelberg recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	430	<=1	32	13.3							58.6	1.9	0.7	16.0	9.5	**4.0**	**9.3**			
	ceftiofur	430	0.50	>8	13.3						51.2	34.9	0.5	0.2	**0.2**	**13.0**					
	ceftriaxone	430	<=0.25	16	0.0					86.3		0.2	0.2		1.9	9.1	2.3				
	ciprofloxacin	430	<=0.015	<=0.015	0.0	95.8	1.9	0.2	1.2	0.7	0.2										
II	amikacin	430	1	2	0.0						2.1	83.7	12.1	2.1							
	ampicillin	430	2	>32	39.1							45.6	14.4	0.7		0.2		**39.1**			
	cefoxitin	430	2	32	11.9							48.1	36.0	2.3	0.7	0.9	**7.0**	**4.9**			
	gentamicin	430	<=0.25	0.50	3.3					77.7	17.0	0.9		0.7	0.5	**2.6**	**0.7**				
	kanamycin	430	<=8	<=8	1.2										98.6	0.2		**0.2**	**0.9**		
	nalidixic acid	430	4	4	1.9								23.3	73.5	0.9	0.5		**1.9**			
	streptomycin	430	<=32	64	13.3												86.7	**5.8**	**7.4**		
	trimethoprim-sulphamethoxazole	430	<=0.12	0.25	2.3				81.2	16.3			0.2	**0.5**	**1.9**						
III	chloramphenicol	430	8	8	1.4									15.8	82.1	0.7	**0.2**	**1.2**			
	sulfisoxazole	430	32	64	7.0											3.7	74.4	12.3	2.1	0.5	**7.0**
	tetracycline	430	<=4	>32	13.5									86.3	0.2	**1.2**	**0.9**	**11.4**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 38. Distribution of MICs and resistance in *Salmonella* Newport recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	146	<=1	8	8.9							84.9	2.1	0.7	3.4		**3.4**	**5.5**			
	ceftiofur	146	1	1	8.2						41.1	50.0	0.7			**8.2**					
	ceftriaxone	146	<=0.25	<=0.25	1.4					90.4	0.7			0.7	0.7	1.4	4.8	**1.4**			
	ciprofloxacin	146	<=0.015	<=0.015	0.0	95.9			2.7	0.7	0.7										
II	amikacin	146	1	2	0.0						2.1	84.9	12.3	0.7							
	ampicillin	146	<=1	>32	12.3							76.0	11.0	0.7			**0.7**	**11.6**			
	cefoxitin	146	2	4	8.2							11.6	74.0	5.5	0.7		**1.4**	**6.8**			
	gentamicin	146	<=0.25	0.50	0.0					68.5	29.5	2.1									
	kanamycin	146	<=8	<=8	5.5										93.2	0.7	0.7	**1.4**	**4.1**		
	nalidixic acid	146	2	4	4.8								63.7	31.5				**4.8**			
	streptomycin	146	<=32	>64	13.0												87.0	**2.7**	**10.3**		
	trimethoprim-sulphamethoxazole	146	<=0.12	0.25	2.1				84.9	13.0				**0.7**	**1.4**						
III	chloramphenicol	146	4	>32	12.3									79.5	6.8	1.4	**0.7**	**11.6**			
	sulfisoxazole	146	64	>256	12.3											0.7	13.7	56.8	16.4		**12.3**
	tetracycline	146	<=4	>32	18.5									78.8	2.7	**3.4**		**15.1**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 39. Distribution of MICs and resistance in *Salmonella* Paratyphi A and Paratyphi B recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	66	<=1	2	0.0							57.6	40.9			1.5					
	ceftiofur	66	1	1	0.0					1.5	9.1	89.4									
	ceftriaxone	66	<=0.25	<=0.25	0.0					100.0											
	ciprofloxacin	66	0.50	0.50	0.0	13.6	1.5			3.0	81.8										
II	amikacin	66	0.50	1	0.0						77.3	21.2	1.5								
	ampicillin	66	2	4	1.5							7.6	65.2	24.2	1.5			**1.5**			
	cefoxitin	66	4	8	0.0								10.6	77.3	12.1						
	gentamicin	66	<=0.25	<=0.25	0.0					95.5	4.5										
	kanamycin	66	<=8	<=8	0.0										100.0						
	nalidixic acid	66	>32	>32	84.8								9.1	6.1				**84.8**			
	streptomycin	66	<=32	<=32	0.0												100.0				
	trimethoprim-sulphamethoxazole	66	<=0.12	0.25	0.0				72.7	22.7	4.5										
III	chloramphenicol	66	8	8	1.5									6.1	84.8	7.6		**1.5**			
	sulfisoxazole	66	32	64	1.5											22.7	60.6	13.6	1.5		**1.5**
	tetracycline	66	<=4	<=4	1.5									95.5	3.0	**1.5**					
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 40. Distribution of MICs and resistance in *Salmonella* Typhi recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	164	<=1	8	1.8							81.1	1.2	4.9	9.8	1.2	**1.8**				
	ceftiofur	164	0.50	1	1.2					3.7	85.4	9.1	0.6			**1.2**					
	ceftriaxone	164	<=0.25	<=0.25	0.0					97.0	1.8				1.2						
	ciprofloxacin	164	0.25	0.25	0.0	15.9	0.6	3.0	22.0	49.4	8.5		0.6								
II	amikacin	164	1	1	0.0						20.7	76.8	2.4								
	ampicillin	164	<=1	>32	18.3							65.2	15.9	0.6			**0.6**	**17.7**			
	cefoxitin	164	4	4	1.8							34.1	11.6	49.4	3.0		**1.8**				
	gentamicin	164	<=0.25	<=0.25	0.0					95.1	4.9										
	kanamycin	164	<=8	<=8	0.6										98.8	0.6			**0.6**		
	nalidixic acid	164	>32	>32	79.9							0.6	15.2	1.8	1.8	0.6	**0.6**	**79.3**			
	streptomycin	164	<=32	>64	14.0												86.0		**14.0**		
	trimethoprim-sulphamethoxazole	164	<=0.12	>4	15.2				73.8	11.0					**15.2**						
III	chloramphenicol	164	4	>32	16.5								1.2	65.2	17.1			**16.5**			
	sulfisoxazole	164	64	>256	15.2											9.1	40.2	28.7	6.7		**15.2**
	tetracycline	164	<=4	16	10.4									88.4	1.2	**0.6**	**1.8**	**7.9**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 41. Distribution of MICs and resistance in *Salmonella* Typhimurium recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	539	<=1	16	2.2							67.2	2.0	0.9	8.0	19.7	**0.7**	**1.5**			
	ceftiofur	539	1	1	1.5					0.2	19.7	77.4	1.1	0.2		**1.5**					
	ceftriaxone	539	<=0.25	<=0.25	0.0					98.1	0.2	0.2				1.3	0.2				
	ciprofloxacin	539	<=0.015	<=0.015	0.0	92.8	2.0	0.6	0.7	0.7	3.2										
II	amikacin	539	1	2	0.0						1.5	75.5	19.9	2.8	0.4						
	ampicillin	539	<=1	>32	30.2							57.5	10.8	0.6	0.7	0.2	**0.6**	**29.7**			
	cefoxitin	539	2	4	1.7							11.1	74.6	9.8	2.6	0.2	**0.7**	**0.9**			
	gentamicin	539	<=0.25	0.50	1.3					52.3	41.7	3.7	0.7		0.2	**0.7**	**0.6**				
	kanamycin	539	<=8	>64	16.5										82.6	0.9		**0.2**	**16.3**		
	nalidixic acid	539	4	4	2.0							0.2	41.6	52.7	2.6	0.9		**2.0**			
	streptomycin	539	<=32	>64	36.2												63.8	**19.1**	**17.1**		
	trimethoprim-sulphamethoxazole	539	<=0.12	0.25	8.2				65.7	25.4	0.7			**0.2**	**8.0**						
III	chloramphenicol	539	8	>32	25.6									34.9	39.0	0.6	**0.6**	**25.0**			
	sulfisoxazole	539	64	>256	37.7											1.3	41.0	19.3	0.7		**37.7**
	tetracycline	539	<=4	>32	37.7									61.0	1.3	**9.8**	**11.3**	**16.5**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 42. Distribution of MICs and resistance in "Other Serovars" of *Salmonella* isolates recovered from humans; *Surveillance of Human Clinical Isolates*, 2006.

*	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	1150	<=1	<=1	2.6							90.3	2.4	0.9	1.6	2.2	**0.6**	**2.0**			
	ceftiofur	1150	1	1	2.7				0.1	0.8	48.0	47.5	0.6	0.3	**0.2**	**2.5**					
	ceftriaxone	1150	<=0.25	<=0.25	0.3					96.5	0.5	0.1	0.1	0.1	0.3	1.9	0.3	**0.1**	**0.2**		
	ciprofloxacin	1150	<=0.015	<=0.015	0.2	90.7	2.6	1.0	2.1	2.5	0.6	0.3			**0.2**						
II	amikacin	1150	1	2	0.0						1.5	74.7	21.7	2.0	0.1						
	ampicillin	1150	<=1	2	6.9							80.5	11.8	0.6	0.1	0.1		**6.9**			
	cefoxitin	1150	2	4	2.3						0.1	18.1	54.3	23.7	1.3	0.3	**0.8**	**1.5**			
	gentamicin	1150	<=0.25	0.50	1.5					61.4	35.1	1.3	0.3		0.4	**0.9**	**0.6**				
	kanamycin	1150	<=8	<=8	1.3										98.3	0.4		**0.3**	**1.0**		
	nalidixic acid	1150	4	4	5.1						0.2	0.1	46.2	45.9	1.9	0.6	**0.4**	**4.7**			
	streptomycin	1150	<=32	64	10.1												89.9	**5.0**	**5.1**		
	trimethoprim-sulphamethoxazole	1150	<=0.12	0.25	4.0				84.1	11.0	1.0			**0.1**	**3.9**						
III	chloramphenicol	1150	4	8	3.9								0.8	50.1	44.5	0.7	**0.1**	**3.8**			
	sulfisoxazole	1150	64	>256	10.2											3.0	25.6	51.3	9.7	0.3	**10.2**
	tetracycline	1150	<=4	>32	15.0									84.0	1.0	**1.3**	**2.4**	**11.3**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red font indicate the percentage of resistant isolates. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 43. Distribution of MICs and resistance in generic *E. coli* recovered from beef cattle; *Abattoir Surveillance*, 2006.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs														
			MIC50	MIC90		≤ 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	150	4	4	0							5.3	28.0	61.3	5.3						
	ceftiofur	150	0.25	0.50	0.0				10.7	70.7	18.7										
	ceftriaxone	150	<=0.25	<=0.25	0.0					100.0											
	ciprofloxacin	150	<=0.015	<=0.015	0.0	100.0															
II	amikacin	150	1	2	0.0						1.3	60.0	33.3	5.3							
	ampicillin	150	2	4	5.3							14.7	55.3	24.7			**0.7**	**4.7**			
	cefoxitin	150	4	4	0.0							4.7	42.7	44.0	8.7						
	gentamicin	150	0.50	0.50	0.0					41.3	52.0	4.0		0.7	2.0						
	kanamycin	150	<=8	<=8	0.7										96.7	2.0	0.7		**0.7**		
	nalidixic acid	150	2	4	0.0							8.7	80.7	10.7							
	streptomycin	150	<=32	<=32	9.3												90.7	**7.3**	**2.0**		
	trimethoprim-sulphamethoxazole	150	<=0.12	0.25	0.7				78.7	19.3	1.3				**0.7**						
III	chloramphenicol	150	4	8	1.3								3.3	49.3	45.3	0.7		**1.3**			
	sulfisoxazole	150	<=16	>256	15.3											71.3	12.7	0.7			**15.3**
	tetracycline	150	<=4	>32	30.0									65.3	4.7	**4.0**	**2.0**	**24.0**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 44. Distribution of MICs and resistance in *Campylobacter* recovered from beef cattle; *Abattoir Surveillance*, 2006.

*	Antimicrobial	Species	n	MIC Percentiles		%R	<=0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
				MIC50	MIC90															
I	ciprofloxacin	*C. coli*	21	0.125	0.125	0.0		4.8	4.8	81.0	4.8		4.8							
	ciprofloxacin	*C. jejuni*	77	0.064	0.125	0.0		2.6	61.0	33.8	2.6									
	ciprofloxacin	*Campylobacter* spp.	7	0.125	0.125	0.0				100.0										
	telithromycine	*C. coli*	18	2	4	0.0	14.3					9.5	23.8	28.6	23.8					
	telithromycine	*C. jejuni*	59	0.5	2	0.0	23.4					44.2	24.7	7.8						
	telithromycine	*Campylobacter* spp.	5	0.25	1	0.0	28.6		14.3	14.3	14.3		28.6							
II	azythromycin	*C. coli*	21	0.125	0.25	0.0		23.8	19.0	38.1	19.0									
	azythromycin	*C. jejuni*	77	0.064	0.125	0.0		41.6	45.5	9.1	1.3	2.6								
	azythromycin	*Campylobacter* spp.	7	0.125	0.5	0.0		28.6		28.6	14.3	28.6								
	clindamycin	*C. coli*	21	0.5	1	0.0				28.6	14.3	9.5	47.6							
	clindamycin	*C. jejuni*	77	0.125	0.25	0.0			10.4	54.5	28.6	2.6	3.9							
	clindamycin	*Campylobacter* spp.	7	0.25	1	0.0				42.9	14.3	14.3	28.6							
	erythromycin	*C. coli*	21	1	2	0.0					14.3	28.6	14.3	38.1	4.8					
	erythromycin	*C. jejuni*	77	0.25	1	0.0				5.2	49.4	32.5	10.4		2.6					
	erythromycin	*Campylobacter* spp.	7	0.5	4	0.0				28.6		28.6	14.3		28.6					
	gentamicin	*C. coli*	21	0.5	1	0.0				9.5		57.1	33.3							
	gentamicin	*C. jejuni*	77	0.5	1	0.0					3.9	75.3	20.8							
	gentamicin	*Campylobacter* spp.	7	0.25	1	0.0				28.6	42.9		28.6							
	nalidixic acid	*C. coli*	21	8	32	4.8							4.8		19.0	28.6	33.3	9.5		4.8
	nalidixic acid	*C. jejuni*	77	<=4	8	5.2							7.8	10.4	51.9	24.7				5.2
	nalidixic acid	*Campylobacter* spp.	7	64	>64	57.1										28.6		14.3	28.6	28.6
III	florfenicol	*C. coli*	18	1	2	0.0	14.3					9.5	42.9	28.6	4.8					
	florfenicol	*C. jejuni*	59	1	1	0.0	23.4					15.6	61.0							
	florfenicol	*Campylobacter* spp.	5	0.5	1	0.0	28.6				28.6	28.6	14.3							
	tetracycline	*C. coli*	21	32	>64	52.4				23.8	19.0		4.8					4.8	4.8	42.9
	tetracycline	*C. jejuni*	77	16	>64	51.9		3.9	7.8	29.9	5.2	1.3					2.6	2.6	19.5	27.3
	tetracycline	*Campylobacter* spp.	7	0.125	>64	28.6				57.1	14.3							14.3		14.3
IV																				

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Blue numbers in shaded area correspond to isolates tested in 2005 with E-test at a different range. Campylobacter spp. may include some species that are intrinsically resistant to nalidixic acid.

Table 45. Distribution of MICs and resistance in generic *E. coli* recovered from swine; *Abattoir Surveillance*, 2006.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs														
			MIC50	MIC90		≤ 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	115	4	8	0.0							1.7	21.7	43.5	33.0						
	ceftiofur	115	0.25	0.50	0.0				2.6	74.8	22.6										
	ceftriaxone	115	<=0.25	<=0.25	0.0					100.0											
	ciprofloxacin	115	<=0.015	<=0.015	0.0	99.1				0.9											
II	amikacin	115	2	2	0.0						4.3	40.9	50.4	4.3							
	ampicillin	115	4	>32	34.8							5.2	39.1	19.1	1.7			**34.8**			
	cefoxitin	115	4	4	0.0							2.6	37.4	53.9	6.1						
	gentamicin	115	0.50	1	1.7					32.2	56.5	8.7		0.9			**1.7**				
	kanamycin	115	<=8	>64	18.3										80.9	0.9		**0.9**	**17.4**		
	nalidixic acid	115	2	4	0.9							7.8	79.1	11.3	0.9			**0.9**			
	streptomycin	115	<=32	>64	26.1												73.9	**7.0**	**19.1**		
	trimethoprim-sulphamethoxazole	115	0.25	>4	17.4				40.9	27.8	10.4	1.7	1.7		**17.4**						
III	chloramphenicol	115	8	32	20.9									37.4	36.5	5.2	**17.4**	**3.5**			
	sulfisoxazole	115	64	>256	49.6											40.9	8.7	0.9			**49.6**
	tetracycline	115	>32	>32	83.5									16.5			**6.1**	**77.4**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 46. Distribution of MICs and resistance in *Salmonella* recovered from swine; *Abattoir Surveillance*, 2006.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs														
			MIC50	MIC90		≤ 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	145	<=1	16	0.69							72.4	9.7	0.7	6.9	9.7		**0.7**			
	ceftiofur	145	1	1	0.7						39.3	51.7	8.3			**0.7**					
	ceftriaxone	145	<=0.25	<=0.25	0.0					99.3							0.7				
	ciprofloxacin	145	<=0.015	0.03	0.0	84.8	11.0	4.1													
II	amikacin	145	1	2	0.0						20.0	64.8	11.7	1.4	1.4	0.7					
	ampicillin	145	<=1	>32	18.6							63.4	13.1	4.1		0.7	**0.7**	**17.9**			
	cefoxitin	145	2	4	1.4							17.9	38.6	33.8	6.9	1.4	**0.7**	**0.7**			
	gentamicin	145	<=0.25	0.50	1.4					73.8	20.0	3.4	0.7	0.7		**0.7**	**0.7**				
	kanamycin	145	<=8	>64	11.0										89.0			**0.7**	**10.3**		
	nalidixic acid	145	4	4	0.0								24.1	67.6	7.6	0.7					
	streptomycin	145	<=32	>64	30.3												69.7	**13.8**	**16.6**		
	trimethoprim-sulphamethoxazole	145	<=0.12	0.50	6.2				54.5	32.4	4.8	1.4	0.7		**6.2**						
III	chloramphenicol	145	8	>32	13.1									24.1	56.6	6.2	**1.4**	**11.7**			
	sulfisoxazole	145	64	>256	36.6											5.5	29.0	26.2	2.8		**36.6**
	tetracycline	145	<=4	>32	48.3									51.0	0.7		**8.3**	**40.0**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 47. Distribution of MICs and resistance in generic *E. coli* recovered from chickens; *Abattoir Surveillance*, 2006.

*	Antimicrobial	n	MIC Percentiles		%R	Distribution (%) of MICs														
			MIC50	MIC90		≤ 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	166	4	32	26.5							2.4	28.3	27.7	13.3	1.8	**23.5**	**3.0**			
	ceftiofur	166	0.50	>8	21.1				3.6	43.4	24.7	3.6	1.2	2.4	**10.2**	**10.8**					
	ceftriaxone	166	<=0.25	16	0.0					71.7	4.2		0.6	1.8	11.4	7.8	2.4				
	ciprofloxacin	166	<=0.015	<=0.015	0.0	95.2	1.2	0.6	1.2	1.8											
II	amikacin	166	2	2	0.0						3.6	41.0	51.2	3.6	0.6						
	ampicillin	166	4	>32	43.4							11.4	34.9	10.2			**0.6**	**42.8**			
	cefoxitin	166	4	>32	25.9							2.4	25.3	37.3	7.8	1.2	**8.4**	**17.5**			
	gentamicin	166	0.50	8	8.4					23.5	59.6	5.4	1.2		1.8	**4.2**	**4.2**				
	kanamycin	166	<=8	>64	11.4										88.6				**11.4**		
	nalidixic acid	166	2	4	3.0						1.2	13.3	69.3	12.0	1.2		**0.6**	**2.4**			
	streptomycin	166	<=32	>64	33.7												66.3	**13.3**	**20.5**		
	trimethoprim-sulphamethoxazole	166	<=0.12	2	9.6				53.6	24.7	10.2		1.8		**9.6**						
III	chloramphenicol	166	4	8	7.8								4.2	49.4	37.3	1.2		**7.8**			
	sulfisoxazole	166	<=16	>256	37.3											51.8	8.4	1.8	0.6		**37.3**
	tetracycline	166	32	>32	51.2									48.2	0.6	**0.6**	**4.8**	**45.8**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 48. Distribution of MICs and resistance in *Salmonella* recovered from chickens; *Abattoir Surveillance*, 2006.

*	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	187	<=1	16	9.6							82.4	2.1	1.6	2.7	1.6	**0.5**	**9.1**			
	ceftiofur	187	0.50	4	9.6					3.2	55.1	31.0	0.5	0.5		**9.6**					
	ceftriaxone	187	<=0.25	4	0.0					89.8				0.5	2.1	4.8	2.7				
	ciprofloxacin	187	<=0.015	<=0.015	0.0	95.7	4.3														
II	amikacin	187	1	2	0.0						24.1	64.7	9.1	1.6	0.5						
	ampicillin	187	<=1	>32	15.5							78.1	5.9	0.5				**15.5**			
	cefoxitin	187	2	32	10.2							29.9	44.4	14.4	1.1		**6.4**	**3.7**			
	gentamicin	187	<=0.25	0.50	1.6					80.7	15.5	0.5	1.1		0.5	**0.5**	**1.1**				
	kanamycin	187	<=8	<=8	0.0										100.0						
	nalidixic acid	187	4	4	0.0							1.6	39.0	55.1	4.3						
	streptomycin	187	<=32	64	34.8												65.2	**25.1**	**9.6**		
	trimethoprim-sulphamethoxazole	187	<=0.12	0.25	0.5				85.0	12.8	0.5		1.1		**0.5**						
III	chloramphenicol	187	4	8	0.5								1.6	55.1	42.2	0.5		**0.5**			
	sulfisoxazole	187	32	64	6.4											15.0	54.5	23.5	0.5		**6.4**
	tetracycline	187	<=4	>32	36.9									63.1			**2.1**	**34.8**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Number at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 49. Distribution of MICs and resistance in generic *E. coli* recovered from beef in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
I	amoxicillin-clavulanic acid	Ontario	189	4	4	1.1							4.8	42.9	43.4	7.9		**0.5**	**0.5**			
		Québec	109	4	4	0.0							8.3	37.6	46.8	7.3						
		Saskatchewan	123	4	4	0.0							4.9	38.2	52.8	4.1						
	ceftiofur	Ontario	189	0.25	0.50	0.5				15.3	65.1	18.5			0.5	**0.5**						
		Québec	109	0.25	0.50	0.0				14.7	69.7	14.7	0.9									
		Saskatchewan	123	0.25	0.50	0.0				8.9	71.5	19.5										
	ceftriaxone	Ontario	189	<=0.25	<=0.25	0.0					98.9				0.5	0.5						
		Québec	109	<=0.25	<=0.25	0.0					99.1	0.9										
		Saskatchewan	123	<=0.25	<=0.25	0.0					100.0											
	ciprofloxacin	Ontario	189	<=0.015	<=0.015	0.0	99.5				0.5											
		Québec	109	<=0.015	<=0.015	0.0	99.1	0.9														
		Saskatchewan	123	<=0.015	<=0.015	0.0	100.0															
II	amikacin	Ontario	189	1	2	0.0						1.1	49.7	43.4	5.3	0.5						
		Québec	109	1	2	0.0						0.9	53.2	38.5	5.5	1.8						
		Saskatchewan	123	2	2	0.0						1.6	39.0	55.3	4.1							
	ampicillin	Ontario	189	2	4	3.7							24.3	54.5	17.5				**3.7**			
		Québec	109	2	4	3.7							23.9	52.3	19.3	0.9		**0.9**	**2.8**			
		Saskatchewan	123	2	4	0.8							17.1	58.5	23.6				**0.8**			
	cefoxitin	Ontario	189	2	4	1.1						0.5	3.7	53.4	34.4	5.8	1.1	**1.1**				
		Québec	109	2	4	0.0							6.4	46.8	41.3	4.6	0.9					
		Saskatchewan	123	2	4	0.0							3.3	47.2	47.2	2.4						
	gentamicin	Ontario	189	0.50	0.50	0.0					30.2	63.5	5.3		0.5	0.5						
		Québec	109	0.50	0.50	0.0					30.3	62.4	6.4			0.9						
		Saskatchewan	123	0.50	0.50	0.0					23.6	69.9	4.9	1.6								

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 49 (continued). Distribution of MICs and resistance in generic *E. coli* recovered from beef in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	kanamycin	Ontario	189	<=8	<=8	1.1										97.9		1.1		**1.1**		
		Québec	109	<=8	<=8	0.0										99.1		0.9				
		Saskatchewan	123	<=8	<=8	0.0										99.2	0.8					
	nalidixic acid	Ontario	189	2	2	0.5						0.5	18.5	71.4	9.0				**0.5**			
		Québec	109	2	4	0.0						1.8	17.4	67.0	12.8	0.9						
		Saskatchewan	123	2	2	0.0							9.8	82.1	8.1							
II	streptomycin	Ontario	189	<=32	<=32	3.7												96.3	**1.6**	**2.1**		
		Québec	109	<=32	<=32	5.5												94.5	**2.8**	**2.8**		
		Saskatchewan	123	<=32	<=32	1.6												98.4	**1.6**			
	trimethoprim-sulphamethoxazole	Ontario	189	<=0.12	0.25	1.6				84.7	12.2	1.6				**1.6**						
		Québec	109	<=0.12	0.25	1.8				79.8	16.5	1.8				**1.8**						
		Saskatchewan	123	<=0.12	<=0.12	0.0				91.9	6.5	1.6										
	chloramphenicol	Ontario	189	4	8	1.6								6.3	56.1	36.0			**1.6**			
		Québec	109	4	8	2.8								6.4	52.3	38.5		**1.8**	**0.9**			
		Saskatchewan	123	4	8	0.0								7.3	49.6	43.1						
	sulfisoxazole	Ontario	189	<=16	32	6.3											78.8	14.8				**6.3**
III		Québec	109	<=16	>256	12.8											81.7	5.5				**12.8**
		Saskatchewan	123	<=16	32	4.1											81.3	14.6				**4.1**
	tetracycline	Ontario	189	<=4	>32	14.8									81.0	4.2	**2.1**	**1.1**	**11.6**			
		Québec	109	<=4	>32	20.2									78.9	0.9	**2.8**	**0.9**	**16.5**			
		Saskatchewan	123	<=4	8	8.9									87.8	3.3	**0.8**	**1.6**	**6.5**			
IV																						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 50. Distribution of MICs and resistance in generic *E. coli* recovered from pork in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	amoxicillin-clavulanic acid	Ontario	182	4	8	1.1							2.2	41.8	37.4	17.6		**0.5**	**0.5**			
		Québec	57	2	8	0.0							1.8	57.9	28.1	12.3						
		Saskatchewan	49	4	4	0.0							2.0	40.8	53.1	4.1						
	ceftiofur	Ontario	182	0.25	0.50	0.55				19.2	64.3	14.8	0.5	0.5		**0.5**						
		Québec	57	0.25	0.50	0.0				26.3	63.2	10.5										
I		Saskatchewan	49	0.25	0.50	0.0				10.2	75.5	14.3										
	ceftriaxone	Ontario	182	<=0.25	<=0.25	0.0					98.9		0.5			0.5						
		Québec	57	<=0.25	<=0.25	0.0					100.0											
		Saskatchewan	49	<=0.25	<=0.25	0.0					100.0											
	ciprofloxacin	Ontario	182	<=0.015	<=0.015	0.0	99.5	0.5														
		Québec	57	<=0.015	<=0.015	0.0	98.2	1.8														
		Saskatchewan	49	<=0.015	<=0.015	0.0	100.0															
	amikacin	Ontario	182	2	2	0.0						1.1	38.5	51.6	8.8							
		Québec	57	2	4	0.0						3.5	38.6	43.9	14.0							
		Saskatchewan	49	2	2	0.0							26.5	71.4	2.0							
	ampicillin	Ontario	182	2	>32	20.9							12.6	50.5	14.3	1.6			**20.9**			
		Québec	57	2	>32	19.3							24.6	47.4	8.8			**1.8**	**17.5**			
		Saskatchewan	49	2	4	6.1							8.2	73.5	10.2	2.0		**2.0**	**4.1**			
II	cefoxitin	Ontario	182	2	4	1.1							2.7	59.3	33.0	3.8			**1.1**			
		Québec	57	2	4	0.0								68.4	31.6							
		Saskatchewan	49	2	4	0.0							4.1	57.1	32.7	4.1	2.0					
	gentamicin	Ontario	182	0.50	1	0.5					18.1	68.7	12.6					**0.5**				
		Québec	57	0.50	1	3.5					26.3	52.6	15.8		1.8		**1.8**	**1.8**				
		Saskatchewan	49	0.50	0.50	0.0					28.6	63.3	8.2									

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 50 (continued) Distribution of MICs and resistance in generic *E. coli* recovered from pork in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	kanamycin	Ontario	182	<=8	<=8	4.9										94.5	0.5			**4.9**		
		Québec	57	<=8	>64	12.3										86.0	1.8			**12.3**		
		Saskatchewan	49	<=8	<=8	2.0										98.0				**2.0**		
	nalidixic acid	Ontario	182	2	2	0.0							22.0	68.1	9.3	0.5						
		Québec	57	2	4	0.0						1.8	26.3	61.4	10.5							
		Saskatchewan	49	2	4	0.0							16.3	69.4	12.2		2.0					
II	streptomycin	Ontario	182	<=32	64	19.8												80.2	**11.0**	**8.8**		
		Québec	57	<=32	>64	19.3												80.7	**7.0**	**12.3**		
		Saskatchewan	49	<=32	64	10.2												89.8	**6.1**	**4.1**		
	trimethoprim-sulphamethoxazole	Ontario	182	<=0.12	0.50	4.4				68.7	20.3	5.5	0.5	0.5		**4.4**						
		Québec	57	<=0.12	0.25	7.0				75.4	17.5					**7.0**						
		Saskatchewan	49	<=0.12	0.50	2.0				75.5	12.2	10.2				**2.0**						
	chloramphenicol	Ontario	182	4	32	13.7								3.3	52.7	25.8	4.4	**7.1**	**6.6**			
		Québec	57	4	8	3.5								14.0	54.4	26.3	1.8	**3.5**				
		Saskatchewan	49	4	32	12.2								6.1	63.3	14.3	4.1	**4.1**	**8.2**			
	sulfisoxazole	Ontario	182	<=16	>256	26.4											63.2	9.9	0.5			**26.4**
III		Québec	57	<=16	>256	26.3											68.4	5.3				**26.3**
		Saskatchewan	49	<=16	>256	22.4											69.4	8.2				**22.4**
	tetracycline	Ontario	182	8	>32	48.4									50.0	1.6	**0.5**	**6.0**	**41.8**			
		Québec	57	<=4	>32	36.8									63.2			**3.5**	**33.3**			
		Saskatchewan	49	<=4	>32	30.6									65.3	4.1			**30.6**			
IV																						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 51. Distribution of MICs and resistance in generic *E. coli* recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	amoxicillin-clavulanic acid	Ontario	152	4	32	28.9							7.2	21.1	29.6	12.5	0.7	**23.0**	**5.9**			
		Québec	135	4	8	8.1							5.2	28.1	36.3	22.2		**8.1**				
		Saskatchewan	85	4	16	9.4							8.2	36.5	28.2	16.5	1.2	**5.9**	**3.5**			
	ceftiofur	Ontario	152	0.25	8	22.4				5.3	45.4	19.7	0.7		6.6	**14.5**	**7.9**					
		Québec	135	0.25	0.50	5.9				5.9	65.2	20.0	2.2		0.7	**4.4**	**1.5**					
I		Saskatchewan	85	0.25	0.50	5.9				3.5	64.7	22.4		1.2	2.4	**4.7**	**1.2**					
	ceftriaxone	Ontario	152	<=0.25	8	0.0					70.4	0.7	0.7	0.7	3.9	13.8	8.6	1.3				
		Québec	135	<=0.25	<=0.25	0.0					92.6		0.7		0.7	3.7	1.5	0.7				
		Saskatchewan	85	<=0.25	<=0.25	0.0					90.6				3.5	4.7	1.2					
	ciprofloxacin	Ontario	152	<=0.015	<=0.015	0.0	96.7		0.7	0.7	2.0											
		Québec	135	<=0.015	<=0.015	0.0	99.3				0.7											
		Saskatchewan	85	<=0.015	<=0.015	0.0	96.5				3.5											
	amikacin	Ontario	152	2	2	0.0						1.3	38.8	52.6	6.6	0.7						
		Québec	135	2	2	0.0						5.2	30.4	57.8	6.7							
		Saskatchewan	85	2	2	0.0						3.5	37.6	55.3	3.5							
	ampicillin	Ontario	152	4	>32	42.1							14.5	28.3	15.1				**42.1**			
		Québec	135	4	>32	34.8							16.3	31.9	17.0				**34.8**			
		Saskatchewan	85	2	>32	30.6							24.7	31.8	12.9				**30.6**			
II	cefoxitin	Ontario	152	4	>32	28.9							1.3	32.9	30.9	5.3	0.7	**7.2**	**21.7**			
		Québec	135	4	8	7.4							2.2	40.7	40.7	8.1	0.7	**2.2**	**5.2**			
		Saskatchewan	85	4	16	9.4							1.2	36.5	41.2	10.6	1.2	**4.7**	**4.7**			
	gentamicin	Ontario	152	0.50	1	5.9					28.9	57.2	7.2			0.7	**4.6**	**1.3**				
		Québec	135	0.50	16	21.5					17.8	48.9	6.7		2.2	3.0	**12.6**	**8.9**				
		Saskatchewan	85	0.50	1	5.9					23.5	65.9	4.7				**4.7**	**1.2**				

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 51 (continued). Distribution of MICs and resistance in generic *E. coli* recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	kanamycin	Ontario	152	<=8	<=8	6.6										92.1	1.3		0.7	5.9		
		Québec	135	<=8	<=8	6.7										90.4	3.0			6.7		
		Saskatchewan	85	<=8	<=8	8.2										91.8				8.2		
	nalidixic acid	Ontario	152	2	4	3.3							11.8	76.3	8.6			0.7	2.6			
		Québec	135	2	2	0.7							11.1	79.3	8.9				0.7			
		Saskatchewan	85	2	4	3.5						1.2	11.8	72.9	10.6				3.5			
II	streptomycin	Ontario	152	<=32	>64	26.3												73.7	9.2	17.1		
		Québec	135	<=32	>64	43.0												57.0	20.0	23.0		
		Saskatchewan	85	<=32	64	32.9												67.1	23.5	9.4		
	trimethoprim-sulphamethoxazole	Ontario	152	<=0.12	0.50	3.9				73.0	16.4	5.9	0.7			3.9						
		Québec	135	<=0.12	0.50	5.9				57.8	22.2	10.4	2.2	1.5		5.9						
		Saskatchewan	85	<=0.12	0.25	1.2				72.9	20.0	5.9				1.2						
	chloramphenicol	Ontario	152	4	8	3.3								2.0	61.8	31.6	1.3		3.3			
		Québec	135	4	8	2.2								3.0	60.7	32.6	1.5		2.2			
		Saskatchewan	85	4	8	0.0								2.4	57.6	38.8	1.2					
	sulfisoxazole	Ontario	152	<=16	>256	16.4											69.7	13.2	0.7			16.4
III		Québec	135	32	>256	39.3											49.6	11.1				39.3
		Saskatchewan	85	<=16	>256	17.6											63.5	17.6	1.2			17.6
	tetracycline	Ontario	152	<=4	>32	41.4									57.9	0.7		4.6	36.8			
		Québec	135	8	>32	48.9									49.6	1.5		3.7	45.2			
		Saskatchewan	85	<=4	>32	47.1									51.8	1.2		3.5	43.5			
IV																						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 52. Distribution of MICs and resistance in *Salmonella* recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	amoxicillin-clavulanic acid	Ontario	36	<=1	32	13.9							83.3			2.8		**5.6**	**8.3**			
		Québec	33	<=1	8	9.1							81.8	3.0		6.1		**6.1**	**3.0**			
		Saskatchewan	25	<=1	8	4.0							88.0			8.0			**4.0**			
	ceftiofur	Ontario	36	0.50	>8	13.9					2.8	55.6	27.8				**13.9**					
		Québec	33	0.50	2	9.1					9.1	60.6	18.2	3.0			**9.1**					
I		Saskatchewan	25	0.50	1	4.0						52.0	44.0				**4.0**					
	ceftriaxone	Ontario	36	<=0.25	8	0.0					86.1					5.6	5.6	2.8				
		Québec	33	<=0.25	<=0.25	0.0					90.9					3.0	6.1					
		Saskatchewan	25	<=0.25	<=0.25	0.0					96.0						4.0					
	ciprofloxacin	Ontario	36	<=0.015	<=0.015	0.0	91.7	8.3														
		Québec	33	<=0.015	<=0.015	0.0	93.9	6.1														
		Saskatchewan	25	<=0.015	0.03	0.0	84.0	16.0														
	amikacin	Ontario	36	1	1	0.0						22.2	75.0	2.8								
		Québec	33	1	2	0.0						33.3	45.5	18.2	3.0							
		Saskatchewan	25	1	1	0.0						20.0	76.0	4.0								
	ampicillin	Ontario	36	<=1	>32	16.7							83.3						**16.7**			
		Québec	33	<=1	>32	15.2							75.8	9.1					**15.2**			
		Saskatchewan	25	<=1	>32	12.0							84.0	4.0					**12.0**			
II	cefoxitin	Ontario	36	2	32	13.9							50.0	30.6	5.6			**8.3**	**5.6**			
		Québec	33	1	8	9.1							51.5	30.3	6.1	3.0		**9.1**				
		Saskatchewan	25	2	4	4.0							32.0	36.0	28.0			**4.0**				
	gentamicin	Ontario	36	<=0.25	0.50	0.0					86.1	13.9										
		Québec	33	<=0.25	0.50	0.0					75.8	18.2	6.1									
		Saskatchewan	25	<=0.25	0.50	0.0					84.0	16.0										

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 52 (continued). Distribution of MICs and resistance in *Salmonella* recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
				MIC_{50}	MIC_{90}		≤ 0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	> 256
	kanamycin	Ontario	36	<=8	<=8	0.0										100.0						
		Québec	33	<=8	<=8	0.0										100.0						
		Saskatchewan	25	<=8	>64	12.0										88.0				**12.0**		
	nalidixic acid	Ontario	36	4	4	0.0							2.8	22.2	72.2	2.8						
		Québec	33	4	4	0.0								33.3	60.6	6.1						
		Saskatchewan	25	4	4	0.0								4.0	88.0	8.0						
II	streptomycin	Ontario	36	<=32	64	25.0												75.0	**19.4**	**5.6**		
		Québec	33	<=32	>64	39.4												60.6	**18.2**	**21.2**		
		Saskatchewan	25	<=32	64	20.0												80.0	**12.0**	**8.0**		
	trimethoprim-sulphamethoxazole	Ontario	36	<=0.12	0.25	2.8				72.2	25.0				**2.8**							
		Québec	33	<=0.12	0.25	0.0				87.9	12.1											
		Saskatchewan	25	<=0.12	0.25	0.0				84.0	16.0											
	chloramphenicol	Ontario	36	4	8	0.0									52.8	47.2						
		Québec	33	4	8	0.0								6.1	51.5	39.4	3.0					
		Saskatchewan	25	4	8	0.0								4.0	52.0	44.0						
	sulfisoxazole	Ontario	36	32	64	0.0											16.7	61.1	19.4	2.8		
III		Québec	33	32	64	0.0											24.2	54.5	21.2			
		Saskatchewan	25	32	64	0.0											16.0	72.0	12.0			
	tetracycline	Ontario	36	<=4	>32	25.0									75.0			**2.8**	**22.2**			
		Québec	33	<=4	>32	39.4									60.6			**3.0**	**36.4**			
		Saskatchewan	25	<=4	>32	32.0									68.0			**8.0**	**24.0**			
IV																						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 53. Distribution of MICs and resistance in *Campylobacter* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs												
					MIC_{50}	MIC_{90}		≤0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
	ciprofloxacin	*C. coli*	Ontario	17	0.125	0.25	5.9			29.4	52.9	11.8						**5.9**			
	ciprofloxacin	*C. coli*	Québec	24	0.125	0.25	8.3			16.7	41.7	33.3					**8.3**				
	ciprofloxacin	*C. coli*	Saskatchewan	11	0.064	0.125	0.0		18.2	63.6	18.2										
	ciprofloxacin	*C. jejuni*	Ontario	87	0.064	0.125	2.3			78.2	17.2	2.3					**2.3**				
	ciprofloxacin	*C. jejuni*	Québec	75	0.064	0.125	0.0			69.3	25.3	5.3									
	ciprofloxacin	*C. jejuni*	Saskatchewan	40	0.125	0.125	2.5			47.5	47.5	2.5					**2.5**				
	ciprofloxacin	*Campylobacter* spp.	Ontario																		
	ciprofloxacin	*Campylobacter* spp.	Québec	1	0.064	0.064	0.0			100.0											
I	ciprofloxacin	*Campylobacter* spp.	Saskatchewan																		
	telithromycine	*C. coli*	Ontario	17	2	16	17.6					11.8	23.5	11.8	29.4	5.9		**17.6**			
	telithromycine	*C. coli*	Québec	24	1	2	4.2					16.7	16.7	45.8	12.5	4.2		**4.2**			
	telithromycine	*C. coli*	Saskatchewan	11	0.5	1	9.1					45.5	36.4	9.1				**9.1**			
	telithromycine	*C. jejuni*	Ontario	87	0.5	1	1.1	1.1			1.1	17.2	63.2	13.8	1.1		1.1	**1.1**			
	telithromycine	*C. jejuni*	Québec	75	0.5	2	0.0					16.0	64.0	6.7	4.0	6.7	2.7				
	telithromycine	*C. jejuni*	Saskatchewan	40	0.5	1	0.0				2.5	10.0	62.5	22.5	2.5						
	telithromycine	*Campylobacter* spp.	Ontario																		
	telithromycine	*Campylobacter* spp.	Québec	1	0.25	0.25	0.0					100.0									
	telithromycine	*Campylobacter* spp.	Saskatchewan																		
	azythromycin	*C. coli*	Ontario	17	0.064	>64	17.6	5.9	17.6	35.3	23.5										**17.6**
	azythromycin	*C. coli*	Québec	24	0.032	0.125	4.2	12.5	54.2	20.8	4.2	4.2									**4.2**
	azythromycin	*C. coli*	Saskatchewan	11	0.064	0.064	9.1	18.2	27.3	45.5											**9.1**
	azythromycin	*C. jejuni*	Ontario	87	0.032	0.064	1.1	12.6	51.7	32.2	1.1		1.1								**1.1**
II	azythromycin	*C. jejuni*	Québec	75	0.032	64	10.7	4.0	52.0	32.0	1.3									**1.3**	**9.3**
	azythromycin	*C. jejuni*	Saskatchewan	40	0.032	0.064	0.0	5.0	55.0	35.0	5.0										
	azythromycin	*Campylobacter* spp.	Ontario																		
	azythromycin	*Campylobacter* spp.	Québec	1	<=0.016	<=0.016	0.0	100.0													
	azythromycin	*Campylobacter* spp.	Saskatchewan																		

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints. Campylobacter spp. may include some species that are intrinsically resistant to nalidixic acid.

Table 53. (continued). Distribution of MICs and resistance in *Campylobacter* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs												
					MIC_{50}	MIC_{90}		≤0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
	clindamycin	*C. coli*	Ontario	17	0.25	8	17.6			17.6	5.9	29.4	23.5			5.9	**11.8**		**5.9**		
	clindamycin	*C. coli*	Québec	24	0.125	0.5	0.0			25.0	37.5	25.0	8.3			4.2					
	clindamycin	*C. coli*	Saskatchewan	11	0.125	0.25	0.0				63.6	27.3				9.1					
	clindamycin	*C. jejuni*	Ontario	87	0.125	0.25	0.0		2.3	31.0	49.4	13.8	2.3			1.1					
	clindamycin	*C. jejuni*	Québec	75	0.125	1	0.0			16.0	60.0	12.0	1.3	1.3	2.7	6.7					
	clindamycin	*C. jejuni*	Saskatchewan	40	0.125	0.25	0.0			12.5	75.0	12.5									
	clindamycin	*Campylobacter* spp.	Ontario																		
	clindamycin	*Campylobacter* spp.	Québec	1	0.125	0.125	0.0				100.0										
	clindamycin	*Campylobacter* spp.	Saskatchewan																		
	erythromycin	*C. coli*	Ontario	17	1	>64	17.6				11.8	23.5	11.8	29.4	5.9						**17.6**
	erythromycin	*C. coli*	Québec	24	0.25	2	4.2					62.5	16.7	8.3	8.3						**4.2**
	erythromycin	*C. coli*	Saskatchewan	11	0.25	0.5	9.1				9.1	72.7	9.1								**9.1**
	erythromycin	*C. jejuni*	Ontario	87	0.25	0.5	1.1			1.1	20.7	60.9	13.8	1.1				1.1			**1.1**
II	erythromycin	*C. jejuni*	Québec	75	0.25	16	9.3				13.3	62.7	12.0		1.3			1.3		**2.7**	**6.7**
	erythromycin	*C. jejuni*	Saskatchewan	40	0.25	0.5	0.0				20.0	52.5	22.5	5.0							
	erythromycin	*Campylobacter* spp.	Ontario																		
	erythromycin	*Campylobacter* spp.	Québec	1	0.25	0.25	0.0					100.0									
	erythromycin	*Campylobacter* spp.	Saskatchewan																		
	gentamicin	*C. coli*	Ontario	17	0.5	0.5	0.0					17.6	82.4								
	gentamicin	*C. coli*	Québec	24	0.5	0.5	0.0				4.2	29.2	62.5	4.2							
	gentamicin	*C. coli*	Saskatchewan	11	0.5	0.5	0.0					9.1	90.9								
	gentamicin	*C. jejuni*	Ontario	87	0.5	0.5	0.0					13.8	81.6	4.6							
	gentamicin	*C. jejuni*	Québec	75	0.5	0.5	0.0					10.7	88.0	1.3							
	gentamicin	*C. jejuni*	Saskatchewan	40	0.5	0.5	0.0					12.5	82.5	5.0							
	gentamicin	*Campylobacter* spp.	Ontario																		
	gentamicin	*Campylobacter* spp.	Québec	1	0.25	0.25	0.0					100.0									
	gentamicin	*Campylobacter* spp.	Saskatchewan																		

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints. Campylobacter spp. may include some species that are intrinsically resistant to nalidixic acid.

Table 53 (continued). Distribution of MICs and resistance in *Campylobacter* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs												
					MIC_{50}	MIC_{90}		≤0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
	nalidixic acid	*C. coli*	Ontario	17	<=4	16	5.9									52.9	29.4	11.8			**5.9**
	nalidixic acid	*C. coli*	Québec	24	<=4	8	8.3									70.8	20.8				**8.3**
	nalidixic acid	*C. coli*	Saskatchewan	11	<=4	<=4	0.0									100.0					
	nalidixic acid	*C. jejuni*	Ontario	87	<=4	8	2.3									89.7	8.0				**2.3**
II	nalidixic acid	*C. jejuni*	Québec	75	<=4	8	0.0									85.3	14.7				
	nalidixic acid	*C. jejuni*	Saskatchewan	40	<=4	8	2.5									77.5	20.0				**2.5**
	nalidixic acid	*Campylobacter* spp.	Ontario																		
	nalidixic acid	*Campylobacter* spp.	Québec	1	8	8	0.0										100.0				
	nalidixic acid	*Campylobacter* spp.	Saskatchewan																		
	florfenicol	*C. coli*	Ontario	17	1	1	0.0						5.9	88.2	5.9						
	florfenicol	*C. coli*	Québec	24	1	1	0.0						20.8	75.0	4.2						
	florfenicol	*C. coli*	Saskatchewan	11	1	1	0.0						36.4	63.6							
	florfenicol	*C. jejuni*	Ontario	87	0.5	1	0.0						54.0	44.8	1.1						
	florfenicol	*C. jejuni*	Québec	75	1	1	0.0					1.3	34.7	62.7	1.3						
	florfenicol	*C. jejuni*	Saskatchewan	40	1	1	0.0						30.0	67.5	2.5						
	florfenicol	*Campylobacter* spp.	Ontario																		
	florfenicol	*Campylobacter* spp.	Québec	1	1	1	0.0							100.0							
III	florfenicol	*Campylobacter* spp.	Saskatchewan																		
	tetracycline	*C. coli*	Ontario	17	2	>64	47.1				11.8	23.5	11.8		5.9					**17.6**	**29.4**
	tetracycline	*C. coli*	Québec	24	64	>64	58.3				8.3	29.2	4.2					**4.2**	**4.2**	**25.0**	**25.0**
	tetracycline	*C. coli*	Saskatchewan	11	0.125	0.25	9.1				54.5	36.4									**9.1**
	tetracycline	*C. jejuni*	Ontario	87	32	>64	57.5			5.7	23.0	6.9	6.9					**1.1**	**12.6**	**32.2**	**11.5**
	tetracycline	*C. jejuni*	Québec	75	64	>64	68.0			2.7	17.3	8.0	4.0					**2.7**	**8.0**	**44.0**	**13.3**
	tetracycline	*C. jejuni*	Saskatchewan	40	0.25	>64	42.5			2.5	45.0	7.5			2.5				**2.5**	**20.0**	**20.0**
	tetracycline	*Campylobacter* spp.	Ontario																		
	tetracycline	*Campylobacter* spp.	Québec	1	64	64	100.0													**100.0**	
	tetracycline	*Campylobacter* spp.	Saskatchewan																		
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints. Campylobacter spp. may include some species that are intrinsically resistant to nalidixic acid.

Table 54. Distribution of MICs and resistance in *Enterococcus* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
					MIC_{50}	MIC_{90}		≤ 0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2048
	ciprofloxacin	*E. faecalis*	Ontario	147	1	2	0.0			2.0	84.4	13.6											
	ciprofloxacin	*E. faecalis*	Québec	135	1	2	0.0			5.9	81.5	12.6											
	ciprofloxacin	*E. faecalis*	Saskatchewan	80	1	2	0.0			5.0	83.8	11.3											
	ciprofloxacin	*E. faecium*	Ontario	4	2	4	25.0			25.0		50.0	**25.0**										
	ciprofloxacin	*E. faecium*	Québec	4	2	2	0.0				50.0	50.0											
	ciprofloxacin	*E. faecium*	Saskatchewan	2	4	4	100.0						**100.0**										
	ciprofloxacin	*Enterococcus* spp.	Ontario	3	0.25	0.5	0.0		66.7	33.3													
	ciprofloxacin	*Enterococcus* spp.	Québec	4	0.5	1	0.0		50.0	25.0	25.0												
	ciprofloxacin	*Enterococcus* spp.	Saskatchewan	3	1	4	33.3			33.3	33.3		**33.3**										
	daptomycine	*E. faecalis*	Ontario	147	1	1	0.0			41.5	57.8	0.7											
	daptomycine	*E. faecalis*	Québec	135	<=0.5	1	0.0			54.1	45.2	0.7											
	daptomycine	*E. faecalis*	Saskatchewan	80	<=0.5	1	0.0			58.8	40.0	1.3											
	daptomycine	*E. faecium*	Ontario	4	2	2	0.0			25.0		75.0											
	daptomycine	*E. faecium*	Québec	4	2	2	0.0					100.0											
	daptomycine	*E. faecium*	Saskatchewan	2	2	2	0.0			50.0		50.0											
	daptomycine	*Enterococcus* spp.	Ontario	3	<=0.5	4	0.0			66.7			33.3										
I	daptomycine	*Enterococcus* spp.	Québec	4	1	1	0.0			50.0	50.0												
	daptomycine	*Enterococcus* spp.	Saskatchewan	3	2	2	0.0					100.0											
	linezolid	*E. faecalis*	Ontario	147	2	2	0.0			0.7	12.2	87.1											
	linezolid	*E. faecalis*	Québec	135	2	2	0.0			2.2	17.8	80.0											
	linezolid	*E. faecalis*	Saskatchewan	80	2	2	0.0			1.3	17.5	80.0	1.3										
	linezolid	*E. faecium*	Ontario	4	2	2	0.0				50.0	50.0											
	linezolid	*E. faecium*	Québec	4	1	2	0.0				75.0	25.0											
	linezolid	*E. faecium*	Saskatchewan	2	2	2	0.0				50.0	50.0											
	linezolid	*Enterococcus* spp.	Ontario	3	<=0.5	2	0.0			66.7		33.3											
	linezolid	*Enterococcus* spp.	Québec	4	1	2	0.0				75.0	25.0											
	linezolid	*Enterococcus* spp.	Saskatchewan	3	2	2	0.0				33.3	66.7											
	quinupristin-dalfopristin	*E. faecium*	Ontario	4	16	16	75.0					25.0			**75.0**								
	quinupristin-dalfopristin	*E. faecium*	Québec	4	16	16	75.0				25.0				**75.0**								
	quinupristin-dalfopristin	*E. faecium*	Saskatchewan	2	8	8	50.0					50.0		**50.0**									
	quinupristin-dalfopristin	*Enterococcus* spp.	Ontario	3	2	8	33.3				33.3	33.3		**33.3**									
	quinupristin-dalfopristin	*Enterococcus* spp.	Québec	4	4	16	50.0				25.0	25.0	**25.0**		**25.0**								
	quinupristin-dalfopristin	*Enterococcus* spp.	Saskatchewan	3	2	8	33.3				33.3	33.3		**33.3**									

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 54 (Continued). Distribution of MICs and resistance in *Enterococcus* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs															
					MIC_{50}	MIC_{90}		≤ 0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2048
	vancomycin	*E*. faecalis	Ontario	147	1	2	0.0				71.4	28.6											
	vancomycin	*E*. faecalis	Québec	135	1	2	0.0			1.5	70.4	27.4	0.7										
	vancomycin	*E*. faecalis	Saskatchewan	80	1	2	0.0			1.3	76.3	22.5											
	vancomycin	*E*. faecium	Ontario	4	<=0.5	<=0.5	0.0			100.0													
I	vancomycin	*E*. faecium	Québec	4	<=0.5	1	0.0			75.0	25.0												
	vancomycin	*E*. faecium	Saskatchewan	2	<=0.5	<=0.5	0.0			100.0													
	vancomycin	*Enterococcus* spp.	Ontario	3	<=0.5	<=0.5	0.0			100.0													
	vancomycin	*Enterococcus* spp.	Québec	4	<=0.5	2	0.0			75.0		25.0											
	vancomycin	*Enterococcus* spp.	Saskatchewan	3	<=0.5	8	0.0			66.7				33.3									
	erythromycin	*E*. faecalis	Ontario	147	1	>8	38.8			38.8	14.3	8.2			**38.8**								
	erythromycin	*E*. faecalis	Québec	135	2	>8	45.2			38.5	11.1	5.2			**45.2**								
	erythromycin	*E*. faecalis	Saskatchewan	80	1	>8	36.3			40.0	17.5	6.3		**1.3**	**35.0**								
	erythromycin	*E*. faecium	Ontario	4	>8	>8	75.0					25.0		**25.0**	**50.0**								
	erythromycin	*E*. faecium	Québec	4	>8	>8	100.0								**100.0**								
	erythromycin	*E*. faecium	Saskatchewan	2	>8	>8	100.0								**100.0**								
	erythromycin	*Enterococcus* spp.	Ontario	3	<=0.5	>8	33.3			66.7					**33.3**								
	erythromycin	*Enterococcus* spp.	Québec	4	>8	>8	50.0			25.0		25.0			**50.0**								
	erythromycin	*Enterococcus* spp.	Saskatchewan	3	<=0.5	<=0.5	0.0			100.0													
	gentamicin	*E*. faecalis	Ontario	147	<=128	<=128	4.1											95.2	0.7	**0.7**	**0.7**	**2.7**	
	gentamicin	*E*. faecalis	Québec	135	<=128	256	8.9											89.6	1.5	**3.0**	**3.0**	**3.0**	
	gentamicin	*E*. faecalis	Saskatchewan	80	<=128	<=128	5.0											95.0		**1.3**	**2.5**	**1.3**	
	gentamicin	*E*. faecium	Ontario	4	<=128	<=128	0.0											100.0					
II	gentamicin	*E*. faecium	Québec	4	<=128	512	25.0											75.0		**25.0**			
	gentamicin	*E*. faecium	Saskatchewan	2	<=128	<=128	0.0											100.0					
	gentamicin	*Enterococcus* spp.	Ontario	3	<=128	<=128	0.0											100.0					
	gentamicin	*Enterococcus* spp.	Québec	4	<=128	<=128	0.0											100.0					
	gentamicin	*Enterococcus* spp.	Saskatchewan	3	<=128	<=128	0.0											100.0					
	kanamycin	*E*. faecalis	Ontario	147	<=128	>1024	12.2											87.8				**12.2**	
	kanamycin	*E*. faecalis	Québec	135	<=128	>1024	22.2											77.0	0.7			**22.2**	
	kanamycin	*E*. faecalis	Saskatchewan	80	<=128	>1024	17.5											82.5				**17.5**	
	kanamycin	*E*. faecium	Ontario	4	256	512	25.0											25.0	50.0	**25.0**			
	kanamycin	*E*. faecium	Québec	4	>1024	>1024	75.0											25.0		**25.0**		**50.0**	
	kanamycin	*E*. faecium	Saskatchewan	2	256	256	0.0											50.0	50.0				
	kanamycin	*Enterococcus* spp.	Ontario	3	<=128	<=128	0.0											100.0					
	kanamycin	*Enterococcus* spp.	Québec	4	<=128	<=128	0.0											100.0					
	kanamycin	*Enterococcus* spp.	Saskatchewan	3	<=128	256	0.0											66.7	33.3				

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 54 (Continued). Distribution of MICs and resistance in *Enterococcus* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
					MIC_{50}	MIC_{90}		≤ 0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2048
	lincomycin	*E. faecalis*	Ontario	4	>32	>32	75.0							25.0			**75.0**						
	lincomycin	*E. faecalis*	Québec	4	>32	>32	100.0										**100.0**						
	lincomycin	*E. faecalis*	Saskatchewan	2	>32	>32	100.0										**100.0**						
	lincomycin	*Enterococcus* spp.	Ontario	3	>32	>32	66.7								33.3		**66.7**						
	lincomycin	*Enterococcus* spp.	Québec	4	>32	>32	75.0								25.0		**75.0**						
	lincomycin	*Enterococcus* spp.	Saskatchewan	3	16	32	33.3								66.7	**33.3**							
	penicillin	*E. faecalis*	Ontario	147	4	4	0.0					25.9	72.8	1.4									
	penicillin	*E. faecalis*	Québec	135	4	4	0.0			0.7	0.7	28.9	69.6										
	penicillin	*E. faecalis*	Saskatchewan	80	4	4	0.0			1.3	1.3	21.3	76.3										
	penicillin	*E. faecium*	Ontario	4	16	>16	50.0				25.0			25.0	**25.0**	**25.0**							
	penicillin	*E. faecium*	Québec	4	16	16	75.0							25.0	**75.0**								
	penicillin	*E. faecium*	Saskatchewan	2	>16	>16	100.0								**50.0**	**50.0**							
	penicillin	*Enterococcus* spp.	Ontario	3	1	2	0.0			33.3	33.3	33.3											
	penicillin	*Enterococcus* spp.	Québec	4	1	1	0.0			50.0	50.0												
	penicillin	*Enterococcus* spp.	Saskatchewan	3	1	>16	33.3				66.7					**33.3**							
	streptomycin	*E. faecalis*	Ontario	147	<=512	>2048	17.7													82.3	1.4	0.7	**15.6**
II	streptomycin	*E. faecalis*	Québec	135	<=512	>2048	34.1													65.9	1.5	8.1	**24.4**
	streptomycin	*E. faecalis*	Saskatchewan	80	<=512	>2048	26.3													73.8		1.3	**25.0**
	streptomycin	*E. faecium*	Ontario	4	1024	1024	50.0													50.0	**50.0**		
	streptomycin	*E. faecium*	Québec	4	1024	1024	50.0													50.0	**50.0**		
	streptomycin	*E. faecium*	Saskatchewan	2	2048	2048	50.0													50.0		**50.0**	
	streptomycin	*Enterococcus* spp.	Ontario	3	<=512	1024	33.3													66.7	**33.3**		
	streptomycin	*Enterococcus* spp.	Québec	4	<=512	1024	25.0													75.0	**25.0**		
	streptomycin	*Enterococcus* spp.	Saskatchewan	3	<=512	<=512	0.0													100.0			
	tylosin	*E. faecalis*	Ontario	147	2	>32	38.8			0.7	49.0	11.6					**38.8**						
	tylosin	*E. faecalis*	Québec	135	2	>32	45.2			1.5	44.4	7.4	1.5			**0.7**	**44.4**						
	tylosin	*E. faecalis*	Saskatchewan	80	1	>32	36.3		1.3	1.3	51.3	10.0					**36.3**						
	tylosin	*E. faecium*	Ontario	4	>32	>32	50.0					25.0	25.0				**50.0**						
	tylosin	*E. faecium*	Québec	4	>32	>32	100.0										**100.0**						
	tylosin	*E. faecium*	Saskatchewan	2	>32	>32	100.0										**100.0**						
	tylosin	*Enterococcus* spp.	Ontario	3	4	>32	33.3					33.3	33.3				**33.3**						
	tylosin	*Enterococcus* spp.	Québec	4	>32	>32	50.0		25.0		25.0						**50.0**						
	tylosin	*Enterococcus* spp.	Saskatchewan	3	2	4	0.0				33.3	33.3	33.3										

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 54 (Continued). Distribution of MICs and resistance in *Enterococcus* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs														
					MIC_{50}	MIC_{90}		≤ 0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2048
	bacitracin	*E. faecalis*	Ontario	147	>128	>128	73.5							0.7	2.7	14.3	8.8	**1.4**	**72.1**				
	bacitracin	*E. faecalis*	Québec	135	>128	>128	63.0							2.2	4.4	20.0	10.4	**1.5**	**61.5**				
	bacitracin	*E. faecalis*	Saskatchewan	80	>128	>128	81.3							2.5	1.3	8.8	6.3	**1.3**	**80.0**				
	bacitracin	*E. faecium*	Ontario	4	>128	>128	100.0												**100.0**				
	bacitracin	*E. faecium*	Québec	4	>128	>128	100.0												**100.0**				
	bacitracin	*E. faecium*	Saskatchewan	2	>128	>128	100.0												**100.0**				
	bacitracin	*Enterococcus* spp.	Ontario	3	>128	>128	66.7							33.3					**66.7**				
	bacitracin	*Enterococcus* spp.	Québec	4	>128	>128	50.0							25.0			25.0		**50.0**				
	bacitracin	*Enterococcus* spp.	Saskatchewan	3	64	>128	33.3							33.3			33.3		**33.3**				
	chloramphenicol	*E. faecalis*	Ontario	147	8	8	0.7							97.3	2.0		**0.7**						
	chloramphenicol	*E. faecalis*	Québec	135	8	8	2.2					1.5	2.2	91.9	2.2		**2.2**						
	chloramphenicol	*E. faecalis*	Saskatchewan	80	8	8	0.0					2.5	1.3	93.8	2.5								
	chloramphenicol	*E. faecium*	Ontario	4	8	8	0.0						25.0	75.0									
	chloramphenicol	*E. faecium*	Québec	4	8	8	0.0						50.0	50.0									
	chloramphenicol	*E. faecium*	Saskatchewan	2	8	8	0.0							100.0									
	chloramphenicol	*Enterococcus* spp.	Ontario	3	4	8	0.0						66.7	33.3									
	chloramphenicol	*Enterococcus* spp.	Québec	4	8	8	0.0						25.0	75.0									
III	chloramphenicol	*Enterococcus* spp.	Saskatchewan	3	4	8	0.0						66.7	33.3									
	nitrofurantoin	*E. faecalis*	Ontario	147	16	16	0.0							46.3	49.7	1.4	2.7						
	nitrofurantoin	*E. faecalis*	Québec	135	8	16	0.0							51.9	42.2		5.9						
	nitrofurantoin	*E. faecalis*	Saskatchewan	80	16	16	0.0							50.0	48.8		1.3						
	nitrofurantoin	*E. faecium*	Ontario	4	>64	>64	50.0										50.0	**50.0**					
	nitrofurantoin	*E. faecium*	Québec	4	>64	>64	100.0											**100.0**					
	nitrofurantoin	*E. faecium*	Saskatchewan	2	>64	>64	50.0										50.0	**50.0**					
	nitrofurantoin	*Enterococcus* spp.	Ontario	3	64	>64	33.3										66.7	**33.3**					
	nitrofurantoin	*Enterococcus* spp.	Québec	4	>64	>64	50.0							25.0			25.0	**50.0**					
	nitrofurantoin	*Enterococcus* spp.	Saskatchewan	3	64	>64	33.3						33.3				33.3	**33.3**					
	tetracycline	*E. faecalis*	Ontario	147	>32	>32	83.7						16.3		**0.7**	**12.9**	**70.1**						
	tetracycline	*E. faecalis*	Québec	135	>32	>32	83.7						16.3			**3.7**	**80.0**						
	tetracycline	*E. faecalis*	Saskatchewan	80	>32	>32	76.3						23.8		**1.3**	**6.3**	**68.8**						
	tetracycline	*E. faecium*	Ontario	4	>32	>32	75.0						25.0				**75.0**						
	tetracycline	*E. faecium*	Québec	4	>32	>32	100.0										**100.0**						
	tetracycline	*E. faecium*	Saskatchewan	2	>32	>32	100.0									**50.0**	**50.0**						
	tetracycline	*Enterococcus* spp.	Ontario	3	16	>32	66.7						33.3		**33.3**		**33.3**						
	tetracycline	*Enterococcus* spp.	Québec	4	32	>32	50.0						25.0	25.0		**25.0**	**25.0**						
	tetracycline	*Enterococcus* spp.	Saskatchewan	3	32	>32	66.7						33.3			**33.3**	**33.3**						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 54 (Continued). Distribution of MICs and resistance in *Enterococcus* species recovered from chicken in Saskatchewan, Ontario, and Québec; *Retail Meat Surveillance*, 2006.

*	Antimicrobial	Species	Province	n	MIC Percentiles		%R	Distribution (%) of MICs													
					MIC_{50}	MIC_{90}		≤ 0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	> 2048
	flavomycin	*E*. faecalis	Ontario	147	<=1	<=1	0.0				100.0												
	flavomycin	*E*. faecalis	Québec	135	<=1	<=1	0.7				99.3						**0.7**						
	flavomycin	*E*. faecalis	Saskatchewan	80	<=1	<=1	0.0				100.0												
	flavomycin	*E*. faecium	Ontario	4	>32	>32	50.0							50.0			**50.0**						
IV	flavomycin	*E*. faecium	Québec	4	4	4	0.0					50.0	50.0										
	flavomycin	*E*. faecium	Saskatchewan	2	16	16	0.0						50.0		50.0								
	flavomycin	*Enterococcus* spp.	Ontario	3	2	>32	33.3				33.3	33.3					**33.3**						
	flavomycin	*Enterococcus* spp.	Québec	4	>32	>32	75.0				25.0						**75.0**						
	flavomycin	*Enterococcus* spp.	Saskatchewan	3	>32	>32	100.0									**33.3**	**66.7**						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 55. Distribution of MICs and resistance in all generic swine *E. coli* isolates; *On-Farm Surveillance*, 2006.

*	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
	amoxicillin-clavulanic acid	2197	4	8	1.6							3.6	28.5	36.8	28.7	0.8	**1.5**	**0.1**			
	ceftiofur	2197	0.25	0.50	1.0				8.0	67.8	22.4	0.5		0.3	**0.4**	**0.6**					
I	ceftriaxone	2197	<=0.25	<=0.25	0.0					98.2	0.4	0.1		0.2	0.6	0.5	0.05				
	ciprofloxacin	2197	<=0.015	<=0.015	0.05	99.6	0.4								**0.05**						
	amikacin	2197	2	2	0.0						4.9	41.0	47.8	5.6	0.7	0.05					
	ampicillin	2197	4	>32	35.6							12.3	35.2	14.8	1.2	0.9	**0.1**	**35.5**			
	cefoxitin	2197	4	4	1.3						0.2	2.6	43.0	46.2	6.2	0.5	**0.3**	**1.0**			
	gentamicin	2197	0.50	1	1.5					26.7	61.6	8.1	0.9	0.5	0.8	**0.9**	**0.5**				
II	kanamycin	2197	<=8	>64	13.9										85.5	0.4	0.1	**0.8**	**13.1**		
	nalidixic acid	2197	2	2	0.2						0.3	13.6	78.2	7.7			**0.1**	**0.05**			
	streptomycin	2197	<=32	>64	39.7												60.3	**17.9**	**21.8**		
	trimethoprim-sulphamethoxazole	2197	<=0.12	>4	13.9				49.2	26.2	9.3	1.1	0.2	**0.05**	**13.9**						
	chloramphenicol	2197	8	>32	20.3								3.6	37.5	35.2	3.5	**10.1**	**10.2**			
III	sulfisoxazole	2197	>256	>256	51.4											41.0	6.1	1.4	0.1		**51.4**
	tetracycline	2197	>32	>32	79.2									19.7	1.0	**0.4**	**4.2**	**74.7**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 56. Distribution of MICs and resistance of all swine *Salmonella* isolates; *On-Farm Surveillance*, 2006.

*	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
	amoxicillin-clavulanic acid	94	<=1	8	1.1							69.1	3.2	4.3	20.2	2.1		**1.1**			
	ceftiofur	94	1	1	1.1						39.4	55.3	4.3			**1.1**					
I	ceftriaxone	94	<=0.25	<=0.25	0.00					98.9							1.1				
	ciprofloxacin	94	<=0.015	0.03	0.00	86.2	12.8	1.1													
	amikacin	94	1	2	0.00						16.0	60.6	18.1	4.3	1.1						
	ampicillin	94	<=1	>32	28.7							61.7	5.3	2.1	1.1	1.1	**1.1**	**27.7**			
	cefoxitin	94	2	4	1.1							17.0	44.7	31.9	5.3			**1.1**			
II	gentamicin	94	<=0.25	0.50	0.00					72.3	25.5	1.1	1.1								
	kanamycin	94	<=8	>64	11.7										87.2	1.1			**11.7**		
	nalidixic acid	94	4	4	0.00								29.8	63.8	6.4						
	streptomycin	94	<=32	>64	40.4												59.6	**11.7**	**28.7**		
	trimethoprim-sulphamethoxazole	94	<=0.12	1	6.4				51.1	27.7	11.7	2.1	1.1	**1.1**	**5.3**						
	chloramphenicol	94	8	>32	11.7									29.8	55.3	3.2		**11.7**			
III	sulfisoxazole	94	64	>256	45.7											5.3	25.5	20.2	3.2		**45.7**
	tetracycline	94	>32	>32	57.4									42.6		**2.1**	**4.3**	**51.1**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Number at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 57. Distribution of MICs and resistance in all swine *Enterococcus* isolates; *On-Farm Surveillance*, 2006.

*	Antimicrobial	Species	n	MIC percentile		%R	Distribution (%) ofMICs																	
				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	1024	2048	> 2048
I	ciprofloxacin	*E. faecalis*	642	1	2	1.6					1.6	9.8	76.8	10.3	**0.3**	**1.2**									
	ciprofloxacin	*E. faecium*	37	1	4	13.5					2.7	13.5	37.8	32.4	**5.4**	**8.1**									
	ciprofloxacin	*Enterococcus* spp.	188	0.5	2	2.7				1.1	16.5	40.4	26.6	12.8	**1.6**	**1.1**									
	daptomycin	*E. faecalis*	642	1	1	0.0						26.3	68.2	4.5	0.8	**0.2**									
	daptomycin	*E. faecium*	37	2	2	0.0							32.4	59.5	8.1										
	daptomycin	*Enterococcus* spp.	188	1	4	0.0						30.9	28.7	29.3	9.6	**1.6**									
	linezolide	*E. faecalis*	642	2	2	0.0						1.2	36.8	62.0											
	linezolide	*E. faecium*	37	2	2	0.0							27.0	73.0											
	linezolide	*Enterococcus* spp.	188	1	2	0.0						7.4	45.7	46.3	0.5										
	quinupristin-dalfopristin	*E. faecium*	37	2	4	24.3							16.2	59.5	**18.9**	**2.7**	**2.7**								
	quinupristin-dalfopristin	*Enterococcus* spp.	188	2	8	45.2							11.7	43.1	**21.8**	**19.7**	**3.7**								
	tigecyclin*	*E. faecalis*	253	0.25	0.25	1.2	0.4	0.4	2.4	45.8	42.3	7.5	**1.2**												
	tigecyclin*	*E. faecium*	25	0.12	0.25	0.0			4.0	56.0	32.0	8.0													
	tigecyclin*	*Enterococcus* spp.	74	0.12	0.25	0.0		2.7	20.3	44.6	27.0	5.4													
	vancomycin	*E. faecalis*	642	1	2	0.0						5.8	73.7	20.1	0.5										
	vancomycin	*E. faecium*	37	<=0.5	2	0.0						78.4	5.4	16.2											
	vancomycin	*Enterococcus* spp.	188	<=0.5	8	0.0						55.3	21.3	3.2	10.1	9.6	0.5								
II	erythromycin	*E. faecalis*	642	>8	>8	77.9						8.3	10.3	3.6		**0.3**	**77.6**								
	erythromycin	*E. faecium*	37	2	>8	35.1						13.5	16.2	27.0	8.1		**35.1**								
	erythromycin	*Enterococcus* spp.	188	>8	>8	62.2						22.9	6.9	4.3	3.7	**1.1**	**61.2**								
	gentamicin	*E. faecalis*	642	<=128	<=128	5.6														93.0	1.4	**2.6**	**1.1**	**1.9**	
	gentamicin	*E. faecium*	37	<=128	<=128	0.0														100.0					
	gentamicin	*Enterococcus* spp.	188	<=128	<=128	2.7														96.3	1.1	**1.6**	**0.5**	**0.5**	
	kanamycin	*E. faecalis*	642	<=128	>1024	37.9														61.8	0.3	**0.3**		**37.5**	
	kanamycin	*E. faecium*	37	256	>1024	27.0														35.1	37.8	**5.4**		**21.6**	
	kanamycine	*Enterococcus* spp.	188	<=128	>1024	20.7														78.7	0.5	**0.5**	**1.6**	**18.6**	
	lincomycin	*E. faecalis*	37	16	>32	48.6							13.5			2.7	35.1	**2.7**	**45.9**						
	lincomycin	*Enterococcus* spp.	188	>32	>32	80.9							1.6	0.5	0.5	0.5	16.0	**6.4**	**74.5**						
	penicillin	*E. faecalis*	642	4	4	1.7						1.4	2.3	12.8	80.5	1.2	**0.3**	**1.4**							
	penicillin	*E. faecium*	37	4	16	10.8							10.8	16.2	48.6	13.5	**10.8**								
	penicillin	*Enterococcus* spp.	188	1	8	7.4						33.5	20.7	10.1	17.6	10.6	**3.7**	**3.7**							

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints. Bacitracin test were undertaken on all isolates except those form Alberta and Saskatchewan. Tigecyclin was tested only on Alberta and Saskatchewan isolates. The dashed zone indicate a dilution tested only on those isolates from outside Alberta and Saskatchewan.

Table 57 (continued). Distribution of MICs and resistance in all swine *Enterococcus* isolates; *On-Farm Surveillance*, 2006.

*	Antimicrobial	Species	n	MIC percentile		%R	Distribution (%) ofMICs																
				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	1024	2048	> 2048
II	streptomycin	*E. faecalis*	642	2048	>2048	50.6																49.4	**0.6**	**6.5**	**43.5**
	streptomycin	*E. faecium*	37	<=512	2048	18.9																81.1		**10.8**	**8.1**
	streptomycin	*Enterococcus* spp.	188	<=512	>2048	31.9																68.1	**11.7**	**10.1**	**10.1**
	tylosin	*E. faecalis*	642	>32	>32	77.9						1.1	17.0	3.3	0.8			**0.3**	**77.6**						
	tylosin	*E. faecium*	37	4	>32	35.1							13.5	13.5	35.1	2.7			**35.1**						
	tylosin	*Enterococcus* spp.	188	>32	>32	68.1					0.5	1.1	13.8	14.4	2.1			**0.5**	**67.6**						
III	bacitracin*	*E. faecalis*	389	32	64	8.0										2.6	13.1	56.8	19.5	**1.3**	**6.7**				
	bacitracin*	*E. faecium*	12	32	128	16.7										25.0		50.0	8.3	**8.3**	**8.3**				
	bacitracin*	*Enterococcus* spp.	114	16	>128	17.5										47.4	6.1	20.2	8.8	**2.6**	**14.9**				
	chloramphenicol	*E. faecalis*	642	8	16	6.9								0.3	7.0	77.7	8.1	**1.7**	**5.1**						
	chloramphenicol	*E. faecium*	37	8	8	0.0									43.2	56.8									
	chloramphenicol	*Enterococcus* spp.	188	8	8	4.8								0.5	39.9	53.2	1.6	**3.2**	**1.6**						
	nitrofurantoin	*E. faecalis*	642	8	16	0.8								0.2		63.7	28.7	3.4	3.3	**0.8**					
	nitrofurantoin	*E. faecium*	37	64	64	5.4										2.7	5.4	5.4	81.1	**5.4**					
	nitrofurantoin	*Enterococcus* spp.	188	32	>64	27.1									4.8	25.0	9.0	19.1	14.9	**27.1**					
	tetracycline	*E. faecalis*	642	>32	>32	93.9									6.1			**0.6**	**3.3**	**90.0**					
	tetracycline	*E. faecium*	37	32	>32	56.8									43.2			**2.7**	**8.1**	**45.9**					
	tetracycline	*Enterococcus* spp.	188	>32	>32	83.0									16.5	0.5		**3.7**	**6.9**	**72.3**					
IV	flavomycin	*E. faecalis*	642	<=1	<=1	3.9							94.4	0.9	0.2	0.5	0.2	**3.9**							
	flavomycin	*E. faecium*	37	32	>32	78.4							2.7		2.7	8.1	8.1	**59.5**	**18.9**						
	flavomycin	*Enterococcus* spp.	188	32	>32	54.8							22.9	6.4	7.4	5.3	3.2	**31.9**	**22.9**						

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints. Bacitracin test were undertaken on all isolates except those form Alberta and Saskatchewan. Tigecyclin was tested only on Alberta and Saskatchewan isolates. The dashed zone indicate a dilution tested only on those isolates from outside Alberta and Saskatchewan.

Table 58. Distribution of MICs and resistance in bovine *Salmonella* isolates; *Surveillance of Animal Clinical Isolates*, 2006.

*	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
	amoxicillin-clavulanic acid	152			7.24							71.7	4.6		2.0	14.5	**2.6**	**4.6**			
	ceftiofur	152	0.50	1	7.2						64.5	27.6	0.7			**7.2**					
I	ceftriaxone	152	<=0.25	<=0.25	0.7					92.8						4.6	2.0	**0.7**			
	ciprofloxacin	152	<=0.015	<=0.015	0.0	98.0	2.0														
	amikacin	152	1	2	0.0						12.5	71.7	13.8	2.0							
	ampicillin	152	<=1	>32	24.3							71.7	3.3			0.7	**0.7**	**23.7**			
	cefoxitin	152	2	4	7.2							28.3	49.3	13.8	1.3		**3.9**	**3.3**			
II	gentamicin	152	<=0.25	0.50	1.3					68.4	25.7	3.9			0.7	**0.7**	**0.7**				
	kanamycin	152	<=8	>64	17.1										82.9				**17.1**		
	nalidixic acid	152	4	4	0.0								44.7	54.6	0.7						
	streptomycin	152	<=32	>64	19.1												80.9	**4.6**	**14.5**		
	trimethoprim-sulphamethoxazole	152	<=0.12	0.25	3.3				75.7	19.7	1.3				**3.3**						
	chloramphenicol	152	4	>32	19.7								6.6	50.7	23.0			**19.7**			
III	sulfisoxazole	152	32	>256	23.7											2.6	50.0	22.4	1.3		**23.7**
	tetracycline	152	<=4	>32	23.0									77.0		**0.7**	**7.2**	**15.1**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 59. Distribution of MICs and resistance in swine *Salmonella* isolates; *Surveillance of Animal Clinical Isolates*, 2006.

*	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	204	2	16	3.92							45.6	9.3	3.4	9.3	28.4	**1.5**	**2.5**			
I	ceftiofur	204	1	1	3.4				1.0	0.5	36.3	56.4	2.5			**3.4**					
I	ceftriaxone	204	<=0.25	<=0.25	0.0					96.6					0.5	1.5	1.5				
I	ciprofloxacin	204	<=0.015	<=0.015	0.0	92.6	6.9	0.5													
II	amikacin	204	1	2	0.0						7.8	75.0	14.7	2.5							
II	ampicillin	204	4	>32	47.1							44.1	3.9	2.5		2.5	**2.9**	**44.1**			
II	cefoxitin	204	2	4	3.4							7.4	63.2	23.5	2.0	0.5	**1.0**	**2.5**			
II	gentamicin	204	<=0.25	0.50	2.5					59.8	34.3	2.5			1.0	**1.5**	**1.0**				
II	kanamycin	204	<=8	>64	25.5										74.5				**25.5**		
II	nalidixic acid	204	4	4	0.0						0.5		35.8	60.8	2.9						
II	streptomycin	204	<=32	>64	45.6												54.4	**26.0**	**19.6**		
II	trimethoprim-sulphamethoxazole	204	0.25	>4	21.1				37.7	35.8	3.4	1.5	0.5		**21.1**						
III	chloramphenicol	204	8	>32	31.9								1.5	18.6	44.1	3.9		**31.9**			
III	sulfisoxazole	204	>256	>256	64.7											2.9	23.0	8.8	0.5		**64.7**
III	tetracycline	204	>32	>32	70.6									29.4			**15.2**	**55.4**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 60. Distribution of MICs and resistance in chicken *Salmonella* isolates; *Surveillance of Animal Clinical Isolates*, 2006.

*	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	115	<=1	16	5.22							84.3	3.5		0.9	6.1	**2.6**	**2.6**			
	ceftiofur	115	1	1	5.2					0.9	32.2	60.0	1.7			**5.2**					
	ceftriaxone	115	<=0.25	<=0.25	0.0					93.9	0.9				2.6	2.6					
	ciprofloxacin	115	<=0.015	0.03	0.0	80.0	20.0														
II	amikacin	115	1	2	0.0						21.7	63.5	14.8								
	ampicillin	115	<=1	>32	12.2							84.3	3.5					**12.2**			
	cefoxitin	115	2	4	5.2							20.9	67.8	4.3	0.9	0.9	**5.2**				
	gentamicin	115	<=0.25	0.50	0.0					72.2	24.3		3.5								
	kanamycin	115	<=8	<=8	0.9										99.1				**0.9**		
	nalidixic acid	115	4	4	0.0							0.9	20.9	77.4	0.9						
	streptomycin	115	<=32	64	13.0												87.0	**9.6**	**3.5**		
	trimethoprim-sulphamethoxazole	115	<=0.12	0.25	0.0				76.5	22.6		0.9									
III	chloramphenicol	115	8	8	1.7								0.9	31.3	64.3	1.7		**1.7**			
	sulfisoxazole	115	32	64	2.6											7.0	80.0	9.6	0.9		**2.6**
	tetracycline	115	<=4	>32	13.0									87.0				**13.0**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Number at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

Table 61. Distribution of MICs and resistance in turkey *Salmonella* isolates; *Surveillance of Animal Clinical Isolates*, 2006.

*	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	49	<=1	>32	38.8							53.1			4.1	4.1	**10.2**	**28.6**			
	ceftiofur	49	1	>8	38.8						34.7	26.5			**2.0**	**36.7**					
	ceftriaxone	49	<=0.25	64	12.2					61.2				2.0	4.1	20.4		**4.1**	**8.2**		
	ciprofloxacin	49	<=0.015	<=0.015	0.0	100.0															
II	amikacin	49	1	2	0.0						18.4	67.3	14.3								
	ampicillin	49	<=1	>32	46.9							51.0	2.0					**46.9**			
	cefoxitin	49	4	>32	38.8							18.4	26.5	14.3	2.0		**22.4**	**16.3**			
	gentamicin	49	<=0.25	>16	28.6					55.1	14.3				2.0	**2.0**	**26.5**				
	kanamycin	49	<=8	>64	18.4										79.6	2.0		**2.0**	**16.3**		
	nalidixic acid	49	4	4	0.0							2.0	38.8	59.2							
	streptomycin	49	64	>64	53.1												46.9	**12.2**	**40.8**		
	trimethoprim-sulphamethoxazole	49	<=0.12	0.25	2.0				69.4	26.5			2.0		**2.0**						
III	chloramphenicol	49	4	8	0.0									51.0	49.0						
	sulfisoxazole	49	32	>256	26.5											2.0	55.1	16.3			**26.5**
	tetracycline	49	<=4	>32	46.9									53.1			**8.2**	**38.8**			
IV																					

Note: * Roman numerals I-IV indicate the ranking of human medicine importance (VDD). The unshaded fields indicate the range tested for each antimicrobial in the plate configuration. Numbers in bold red fonts indicate the percentage of isolates resistant. Numbers at the right of the largest dilution are those isolates with growth in all wells within the tested range, indicating the actual MIC is greater than that range of dilutions. The numbers in the smallest dilution of the range tested indicate isolates susceptible to this level or to lower concentration of the antimicrobial. Solid bars represent the resistance breakpoints. Dotted bars represent the susceptibility breakpoints.

B.3 Summary Tables Across Human and the Agri-Food Sector

Table 62. Summary of selected antimicrobial resistance patterns across humans and the agri-food sector; *CIPARS 2006*.

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C-AMP	ACSSuT	AKSSuT	ACKSSuT R/n (%n) R/N (%N)[2]	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
Surveillance of Human Clinical Isolates									
Human	*S.* Paratyphi A and B (n=66)	9/66 (14%) 9/3205 (<1%)							
	S. Enteritidis (n=710)	538/710 (76%) 538/3205 (17%)	1/710 (<1%) 1/3205 (<1%)			1/710 (<1%) 1/3205 (<1%)			
	S. Heidelberg (n=430)	202/430 (47%) 202/3205 (6%)	47/430 (11%) 47/3205 (1%)				2/430 (<1%) 2/3205 (<1%)		2/430 (<1%) 2/3205 (<1%)
	S. Newport (n=146)	113/146 (77%) 113/3205 (4%)				1/146 (1%) 1/3205 (<1%)	8/146 (1%) 8/3205 (<1%)		4/146 (5%) 4/3205 (<1%)
	S. Typhi (n=164)	29/164 (18%) 29/3205 (<1%)	2/164 (1%) 2/3205 (<1%)	11/164 (7%) 11/3205 (<1%)					
	S. Typhimurium (n=539)	287/539 (53%) 287/3205 (9%)	4/539 (<1%) 4/3205 (<1%)	58/539 (11%) 58/3205 (2%)	5/539 (1%) 5/3205 (<1%)	68/539 (13%) 68/3205 (2%)	4/539 (<1%) 4/3205 (<1%)		
	Other serovars (n=1150)	911/1150 (79%) 911/3205 (28%)	21/1150 (2%) 21/3205 (1%)	17/1150 (1%) 17/3205 (<1%)		1/1150 (<1%) 1/3205 (<1%)	5/1150 (<1%) 5/3205 (<1%)		
Abattoir Surveillance									
Beef Cattle	*E. coli* (n=150)	99/150 (66%)							
	E. coli (n=115)	13/115 (11%)		1/115 (<1%)	3/115 (3%)	3/115 (3%)			
Swine	*S*. Enteritidis (n=1)	1/1 (100%) 1/145 (<1%)							
	S. Heidelberg (n=6)	1/6 (17%) 1/145 (<1%)							
	S. Typhimurium (n=18)	4/18 (22%) 4/145 (3%)		3/18 (17%) 3/145 (2%)	1/18 (6%) 1/145 (<1%)	3/18 (17%) 3/145 (2%)			
	Other serovars (n=120)	57/120 (48%) 57/145 (39%)	1/120 (<1%) 1/145 (<1%)	6/120 (5%) 6/145 (4%)	1/120 (<1%) 1/145 (<1%)	4/120 (3%) 4/145 (3%)			

Note: Blank cells represent values equal to zero (0%).

Table 62 (continued). Summary of selected antimicrobial resistance patterns across humans and the agri-food sector; *CIPARS*, 2006.

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C-AMP	ACSSuT	AKSSuT	ACKSSuT R/n (%n) R/N (%N)[2]	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
Abattoir Surveillance									
Chickens	*E. coli* (n=166)	48/166 (29%)	24/166 (14%)	1/166 (<1%)	3/166 (2%)	1/166 (<1%)	9/166 (5%)	2/166 (1%)	
	S. Enteritidis (n=14)	14/14 (100%) 14/187 (7%)							
	S. Heidelberg (n=38)	19/38 (50%) 19/187 (10%)	7/38 (18%) 7/187 (4%)						
	S. Typhimurium (n=7)	6/7 (86%) 6/187 (3%)	1/7 (14%) 1/187 (<1%)						
	S. Other serovars (n=128)	49/128 (38%) 49/187 (26%)	10/128 (8%) 10/187 (5%)						
Retail Meat Surveillance									
Beef	*E. coli* (n=421)	352/421 (84%)		2/421 (<1%)			1/421 (<1%)		
Pork	*E. coli* (n=288)	150/288 (52%)	1/288 (<1%)	6/288 (2%)	4/288 (1%)				
Chicken	*E. coli* (n=372)	122/372 (33%)	40/372 (11%)	1/372 (<1%)	5/372 (1%)		4/372 (1%)	1/372 (<1%)	1/372 (<1%)
	S. Enteritidis (n=10)	10/10 (100%) 10/94 (11%)							
	S. Heidelberg (n=36)	25/36 (69%) 25/94 (27%)	5/36 (14%) 5/94 (5%)						
	S. Typhimurium (n=1)	1/1 (100%) 1/94 (1%)							
	S. Other serovars (n=47)	14/47 (30%) 14/94 (15%)	4/47 (9%) 4/94 (4%)						
Surveillance of Animal Clinical Isolates									
Bovine	*S*. Enteritidis (n=1)	1/1 (100%) 1/152 (<1%)							
	S. Heidelberg (n=7)	3/7 (43%) 3/152 (2%)	1/7 (14%) 1/152 (<1%)						
	S. Newport (n=5)	1/5 (20%) 1/152 (<1%)							4/5 (80%) 4/152 (3%)
	S. Typhimurium (n=35)	16/35 (46%) 16/152 (11%)	1/35 (3%) 1/152 (<1%)	2/35 (6%) 2/152 (1%)	1/35 (3%) 1/152 (<1%)	7/35 (20%) 7/152 (5%)	1/35 (3%) 1/152 (<1%)		
	S. Other serovars (n=104)	89/104 (86%) 89/152 (59%)		1/104 (<1%) 1/152 (<1%)		7/104 (7%) 7/152 (5%)	1/104 (<1%) 1/152 (<1%)		3/104 (3%) 3/152 (2%)

Note: Blank cells represent values equal to zero (0%).

Table 62 (continued). Summary of selected antimicrobial resistance patterns across humans and the agri-food sector; *CIPARS*, 2006.

Species	Bacterial species	Susceptible to all ATM S/n (%n) S/N (%N)	A2C-AMP	ACSSuT	AKSSuT	ACKSSuT R/n (%n) R/N (%N)[2]	A2C+ ACSSuT	A2C+ AKSSuT	A2C+ ACKSSuT
Surveillance of Animal Clinical Isolates									
Swine	*S*. Enteritidis (n=3)	1/3 (33%) 1/204 (<1%)							
	S. Heidelberg (n=3)								
	S. Typhimurium (n=102)	17/102 (17%) 17/204 (8%)		24/102 (24%) 24/204 (12%)	5/102 (5%) 5/204 (2%)	23/102 (23%) 23/204 (11%)			2/102 (2%) 2/204 (<1%)
	S. Other serovars (n=96)	32/96 (33%) 32/204 (16%)	5/96 (5%) 5/204 (2%)	10/96 (10%) 10/204 (5%)	1/96 (1%) 1/204 (<1%)	4/96 (4%) 4/204 (2%)			
Chickens	*S*. Enteritidis (n=54)	54/54 (100%) 54/115 (47%)							
	S. Heidelberg (n=34)	24/34 (71%) 24/115 (21%)	6/34 (18%) 6/115 (5%)						
	S. Typhimurium (n=2)	1/2 (50%) 1/115 (<1%)		1/2 (50%) 1/115 (<1%)					
	S. Other serovars (n=25)	12/25 (48%) 12/115 (10%)							
Turkeys	*S*. Heidelberg (n=15)	2/15 (13%) 2/49 (4%)	11/15 (73%) 11/49 (22%)						
	S. Other serovars (n=34)	6/34 (18%) 6/49 (12%)	2/34 (6%) 2/49 (4%)					6/34 (18%) 6/49 (12%)	
On-Farm Surveillance									
Swine	*E. coli* (n=2197)	292/2197 (13%)	22/2197 (1%)	84/2197 (4%)	69/2197 (3%)	33/2197 (2%)	9/2197 (<1%)		2/2197 (<1%)
	Salmonella (n=94)	32/94 (34%)		5/94 (5%)	4/94 (4%)	3/94 (3%)			

Note: Blank cells represent values equal to zero (0%).

Table 63. Antimicrobial resistance observed for the most frequent *Salmonella* serovars across human and the agri-food sector; *CIPARS*, 2006.

Species	Most frequent serovars				
	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 11 antimicrobials in resistance pattern
Surveillance of Human Clinical Isolates					
Humans	N=3205	N=2089	N=855	N=247	N=24
	Enteritidis (710)	Enteritidis (538)	Heidelberg (211)	Typhimurium (141)	Newport (6)
	Typhimurium (539)	Typhimurium 9287)	Enteritidis (169)	Typhi (26)	Typhimurium (3)
	Heidelberg (430)	Heidelberg (202)	Typhi (109)	Heidelberg (15)	Heidelberg (2)
	Typhi (164)	Newport (113)	Typhimurium (108)	Newport (10)	Anatum (1)
	Newport (146)	Thompson (84)	Paratyphi A (55)	Paratyphi B var. Java (10)	Concord (1)
	Thompson (92)	Saintpaul (66)	Hadar (51)	Stanley (10)	Mbandaka (1)
	Saintpaul (75)	Agona (34)	Newport (17)	I 4,5,12:i:- (5)	
	Hadar (65)	Paratyphi B var. Java (33)	Stanley (17)	Concord (3)	
Abattoir Surveillance					
Swine	N= 145	N= 63	N= 59	N= 23	
	Derby (38)	Derby (8)	Derby (28)	Typhimuriumvar.5- (9)	
	Typhimuriumvar.5- (21)	Infantis (6)	Typhimurium (7)	Typhimurium (7)	
	Typhimurium (18)	Livingstone (6)	Typhimuriumvar.5- (7)	California (2)	
	Infantis (7)	Schwarzengrund (5)	Heidelberg (5)	Derby (2)	
	Agona (6)	Typhimuriumvar.5- (5)	Agona (2)	Mbandaka (2)	
	Heidelberg (6)	Agona (4)	Anatum (2)	Krefeld (1)	
	Livingstone (6)	Brandenburg (4)			
	Schwarzengrund (6)	Typhimurium (4)			
	Brandenburg (5)	Give (3)			
	Berta (3)	Berta (2)			
	California (3)	Bovismorbificans (2)			
	Give (3)	London (2)			
	Mbandaka (3)	Panama (2)			
Chickens	N= 187	N= 88	N= 95	N= 4	
	Kentucky (80)	Kentucky (26)	Kentucky (51)	Kentucky (3)	
	Heidelberg (38)	Heidelberg (19)	Heidelberg (18)	Heidelberg (1)	
	Enteritidis (14)	Enteritidis (14)	Hadar (7)		
	Hadar (7)	Typhimurium (6)	Schwarzengrund (5)		
	Typhimurium (7)	I4:i:- (4)	Agona (3)		
	I4:i:- (6)	Kiambu (4)	I4:i:- (2)		
	Agona (5)	Senftenberg (4)	Infantis (2)		
	Kiambu (5)	Montevideo (3)	Thompson (2)		
	Schwarzengrund (5)	Agona (2)			
	Senftenberg (4)	Typhimuriumvar.5- (2)			
Retail Surveillance					
Chicken	N= 94	N= 50	N= 42	N= 2	
	Heidelberg (36)	Heidelberg (25)	Kentucky (16)	Heidelberg (1)	
	Kentucky (21)	Enteritidis (10)	Heidelberg (10)	Kentucky (1)	
	Enteritidis (10)	Kentucky (4)	Hadar (6)		
	Hadar (6)	Kiambu (3)	I8,20:i:- (2)		
	Kiambu (4)	Thompson (3)	Typhimuriumvar.5- (2)		
	Indiana (3)	Indiana (2)	Albert (1)		
	Thompson (3)	Infantis (1)	I4:i:- (1)		
	Typhimuriumvar.5- (3)	Typhimurium (1)	I6,8:-:x (1)		
	I8,20:i:- (2)	Typhimuriumvar.5- (1)	Indiana (1)		
			Kiambu (1)		
			Putten (1)		
Surveillance of Animal Clinical Isolates					
Bovine	N= 152	N= 110	N= 12	N= 21	N= 9
	Typhimurium (35)	Kentucky (23)	Typhimurium (6)	Typhimurium (12)	Newport (4)
	Kentucky (25)	Typhimurium (16)	Heidelberg (3)	Typhimuriumvar.5- (8)	Agona (2)
	I6,14,18:-:- (14)	I6,14,18:-:- (14)	Kentucky (2)	Heidelberg (1)	Muenchen (1)
	Typhimuriumvar.5- (9)	Infantis (6)	I4:-:- (1)		Saintpaul (1)
	Heidelberg (7)	Muenchen (6)			Typhimurium (1)
	Muenchen (7)	Thompson (6)			

Note: Most frequent serovars were those representing 2% or more of the isolates within each surveillance component and species. For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium to harmonize serovar classification with the National Microbiology Laboratory.

Table 63 (continued). Antimicrobial resistance observed for the most frequent *Salmonella* serovars across human and the agri-food sector; *CIPARS*, 2006.

Species	Most frequent serovars				
	Total (n)	Susceptible to antimicrobials	1 to 4 antimicrobials in resistance pattern	5 to 8 antimicrobials in resistance pattern	9 to 11 antimicrobials in resistance pattern
Surveillance of Animal Clinical Isolates					
Bovine	N= 152	N= 110	N= 12	N= 21	N= 9
	Infantis (6)	Cerro (3)			
	Thompson (6)	Heidelberg (3)			
	Newport (5)	Muenster (3)			
	Agona (4)	Orion (3)			
Swine	N= 204	N= 50	N= 77	N= 75	N= 2
	Typhimurium (102)	Typhimurium (17)	Typhimurium (30)	Typhimurium (53)	Typhimurium (2)
	Typhimuriumvar.5- (24)	Infantis (7)	Derby (16)	Typhimuriumvar.5- (10)	
	Derby (19)	Brandenburg (3)	Typhimuriumvar.5- (12)	I4:i:- (3)	
	Infantis (9)	I4:i:- (3)	Schwarzengrund (4)	Derby (2)	
	I4:i:- (6)	Berta (2)	Hadar (2)		
	Schwarzengrund (6)	I6,14,18:-:- (2)	Heidelberg (2)		
		Mbandaka (2)	I19:-:- (2)		
		Schwarzengrund (2)	I6,7,14:-:- (2)		
		Typhimuriumvar.5- (2)			
		Worthington (2)			
		Agona (1)			
		California (1)			
		Cerro (1)			
		Derby (1)			
		Enteritidis (1)			
		Give (1)			
		Kentucky (1)			
		Senftenberg (1)			
Chickens	N= 115	N= 91	N= 21	N= 3	
	Enteritidis (54)	Enteritidis (54)	Heidelberg (8)	Heidelberg (2)	
	Heidelberg (34)	Heidelberg (24)	Kentucky (8)	Typhimurium (1)	
	Kentucky (8)	I-:r:2 (3)	I4:-:- (2)		
	I-:r:2 (3)	Montevideo (2)	Hadar (1)		
			I4:r:- (1)		
			Johannesburg (1)		
Turkeys	N= 50	N= 9	N= 24	N= 11	N= 6
	Heidelberg (15)	Saintpaul (3)	Hadar (9)	Heidelberg (9)	Bredeney (6)
	Hadar (9)	Heidelberg (2)	Heidelberg (4)	Brandenburg (1)	
	Bredeney (6)	Brandenburg (1)	Agona (2)	Montevideo (1)	
	Saintpaul (3)	Johannesburg (1)	Litchfield (2)		
	Agona (2)	Ouakam (1)	Senftenberg (2)		
	Brandenburg (2)	Schwarzengrund (1)	Albany (1)		
	Litchfield (2)		Anatum (1)		
	Montevideo (2)		Kentucky (1)		
	Senftenberg (2)		Montevideo (1)		
	Albany (1)		Tennessee (1)		
	Anatum (1)				
	Johannesburg (1)				
	Kentucky (1)				
	Ouakam (1)				
	Schwarzengrund (1)				
	Tennessee (1)				
On-Farm Surveillance					
Swine	N=94	N=33	N=47	N=14	
	Less frequest serovars (45)	Less frequent serovars (22)	Less frequest serovars (22)	Typhimurium var. 5- (8)	
	Derby (18)	Derby (3)	Derby (13)	Typhimurium (3)	
	Typhimurium var. 5- (15)	Typhimurium var. 5- (2)	Typhimurium var. 5- (5)	Derby (2)	
	Typhimurium (6)	London (2)	London (3)	Less frequent serovars (1)	
	London (5)	Typhimurium (2)	Bovismorbificans (3)		
	Bovismorbificans (5)	Bovismorbificans (2)	Typhimurium (1)		

Note: Most frequent serovars were those representing 2% or more of the isolates within each surveillance component and species. For the purpose of this table, *S.* Typhimurium var. 5- results were combined with *S.* Typhimurium to harmonize serovar classification with the National Microbiology Laboratory.

Table 64. Proportion of isolates resistant to one or more antimicrobial in humans and the agri-food sector; *CIPARS* 2006.

Species	Bacterial species	Number of antimicrobials in resistance pattern											
		0	1	2	3	4	5	6	7	8	9	10	11
		Percentage of isolates (%)											
Surveillance of Human Clinical Isolates													
Human	*S*. Enteritidis (N=710)	76	21	2	1	<1	<1	<1					
	S. Heidelberg (N=430)	47	26	8	5	9	2	1	<1	<1	<1	<1	
	S. Newport (N=146)	77	8	1	1	2	2			5	3		1
	S. Paratyphi A and B (N=66)	14	85			2							
	S. Typhi (N=164)	18	61	4	1	1	2	7	7				
	S. Typhimurium (N=539)	53	7	4	6	3	11	10	4	1	<1	<1	
	Other *Salmonella* serovars (N=1150)	79	5	4	3	4	3	1	<1	1	<1	<1	
	Salmonella Total (N=3205)	65	16	4	3	3	3	3	1	1	<1	<1	<1
Abattoir Surveillance													
Beef Cattle	*E. coli* (N=150)	66	15	12	6	1	1						
	C. coli (N=7)	43	57										
	C. jejuni (N=21)	44	55	1									
	Other *Campylobacter* spp. (N=7)	28	57	14									
	Campylobacter total (N=105)	45	55	2									
Swine	*E. coli* (N=115)	11	23	17	17	19	10	2	2				
	S. Enteritidis (N=1)	100											
	S. Heidelberg (N=6)	17	50	33									
	S. Typhimurium (N=18)	22	11	11	17		17	17	6				
	"Other serovars" (N=120)	48	18	4	13	4	10	3	1				
	Salmonella Total (N=145)	43	19	6	12	3	10	4	1				
Chickens	*E. coli* (N=166)	29	10	11	14	13	8	4	1	7	2		
	S. Enteritidis (N=14)	100											
	S. Heidelberg (N=38)	50	16	5	8	18	3						
	S. Typhimurium (N=7)	86				14							
	"Other serovars" (N=128)	38	7	45	2	6		2					
	Salmonella Total (N=187)	47	8	32	3	9	1	2					
Retail Surveillance													
Beef	*E. coli* (N=421)	84	8	4	2	<1	1	<1		<1			
Pork	*E. coli* (N=288)	52	11	12	12	8	3	2					
Chicken	*E. coli* (N=372)	33	14	14	10	16	7	2	2	1		1	
	S. Enteritidis (N=10)	100											
	S. Heidelberg (N=36)	69	6	6	6	11			3				
	S. Typhimurium (N=1)	100											
	"Other serovars" (N=47)	30	19	43		6		2					
	Salmonella Total (N=94)	53	12	23	2	7		1	1				
	C. coli (N=7)	53	33	8	4	4							
	C. jejuni (N=21)	41	53	<1	5								
	Other *Campylobacter* spp. (N=1)		100										
	Campylobacter total (N=255)	43	49	<1	6	<1	<1						
	E. faecalis (N=362)	7	16	33	8	16	10	7	3				
	E. faecium (N=10)			10					20	10	4	20	
	Other *Enterococcus* spp. (N=10)			30	20		10	10	10	20			
	Enterococcus Total (N=382)	6	15	33	8	15	10	7	3	1	1	<1	

Note: Maximum number of antimicrobials tested is 15 for *E. feacalis* because this species is intrinsically resistant to quinupristin-dalfopristin and lincomycin.

Table 64 (continued). Proportion of isolates resistant to one or more antimicrobial in humans and the agri-food sector; *CIPARS* 2006.

Species	Bacterial species	Number of antimicrobials in resistance pattern											
		0	1	2	3	4	5	6	7	8	9	10	11
		Percentage of isolates (%)											
Surveillance of Animal Clinical Isolates													
Bovine	*S*. Enteritidis (N=1)	100											
	S. Heidelberg (N=7)	43	29			14	14						
	S. Newport (N=5)	20									80		
	S. Typhimurium (N=35)	46		6	6	6	11	17	6		3		
	"Other serovars" (N=104)	86	2			1	1	7			3	1	
	Salmonella Total (N=152)	72	3	1	1	3	4	9	1		5	1	
Swine	*S.* Enteritidis (N=3)	33				33	33						
	S. Heidelberg (N=3)			33		33	33						
	S. Typhimurium (N=102)	17	1	9	7	13	23	20	10		1	1	
	"Other serovars" (N=96)	33	13	10	14	9	15	4	1	1			
	Salmonella Total (N=204)	25	6	10	10	12	19	12	5	<1	<1	<1	
Chickens	*S*. Enteritidis (N=54)	100											
	S. Heidelberg (N=34)	71	3	6	3	12	3	3					
	S. Typhimurium (N=2)	50					50						
	"Other serovars" (N=25)	48	8	28	16								
	Salmonella Total (N=115)	79	3	8	4	3	2	1					
Turkeys	*S.* Heidelberg (N=15)	13	13			13	47	13					
	"Other serovars" (N=34)	18	24	12	12	12	3	3				18	
	Salmonella Total (N=49)	16	20	8	8	12	16	6				12	
On-Farm Surveillance													
Swine	*S*. Derby (N=18)	17	11	6	56		11						
	S. Typhimurium var. 5- (N=15)	13		13	13	7	27	20	7				
	S. London (N=5)	40		40		20							
	S. Typhimurium (N=6)	33		17			17	17	17				
	S. Bovismorbificans (N=5)	40		20	40								
	"Other serovars" (N=45)	49	20	7	16	7	2						
	Salmonella Total (N=94)	35	12	11	22	5	9	4	2				

Note: Maximum number of antimicrobials tested is 15 for *E. feacalis* because this species is intrinsically resistant to quinupristin-dalfopristin and lincomycin.

Table 65. Recovery rates observed across surveillance components of the agri-food sector and bacterial species; *CIPARS*, 2002-2006.

CIPARS Component/ Animal species	Province	Year	*E. coli*		*Salmonella*		*Campylobacter*		*Enterococcus*	
			Recovery (%)	n/N	Recovery (%)	n/N	Recovery (%)	n/N	Recovery (%)	n/N
Abattoir Surveillance										
Beef cattle	Canada	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		
Swine	Canada	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				
Chickens	Canada	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				
Retail Meat Surveillance										
Beef	British Columbia	2003	**25%**	2/8	**0%**	0/8	**0%**	0/8	**50%**	4/8
		2005	**93%**	27/29						
		2006	**83%**	5/6						
	Saskatchewan	2005	**79%**	120/151						
		2006	**76%**	123/161						
	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						
	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						
Pork	British Columbia	2003	**38%**	3/8	**0%**	0/8	**0%**	0/8	**75%**	6/8
		2005	**31%**	10/32						
		2006	**20%**	2/8	**33%**	4/12				
	Saskatchewan	2005	**30%**	48/162						
		2006	**30%**	49/165	**2%**	3/134				
	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				
	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				
Chicken	British Columbia	2003	**100%**	8/8	**0%**	0/8	**38%**	3/8	**87%**	7/8
		2005	**95%**	19/20	**13%**	5/39	**69%**	27/39	**100%**	20/20
		2006	**100%**	4/4	**0%**	0/8	**62%**	5/8	**100%**	4/4
	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
	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
	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

Note: n/N=total number of isolates recovered / total number of specimen tested for antimicrobial resistance testing (AMR). Results appearing in gray shaded area indicate isolates that were recovered but not submitted to AMR testing.

Table 66. Information related to specimens received across animal species; *Surveillance of Animal Clinical Isolates*, 2006.

Species	Alberta	Saskatchewan	Manitoba	Ontario	Québec	Nova Scotia	Prince Edward Island
	Number of isolates (percentage of total isolates)						
Bovine (n=152)			2 (1%)	120 (81%)	25 (17%)		1 (1%)
Chickens (n=115)	47 (41%)		6 (5%)	42 (37%)	17 (15%)	3 (3%)	
Swine (n=204)		3 (1%)	13 (7%)	77 (38%)	94 (47%)	6 (3%)	7 (4%)
Turkeys (n=49)				36 (78%)	10 (22%)		

B.4. Antimicrobial Use in Humans

Table 67. Defined daily doses of oral antimicrobials dispensed by retail pharmacies per 1,000 inhabitant-days in Canadian provinces; *CIPARS*, 2006

ATC Class			DDDs/1,000 inhabitant-days								
			AB	BC	MB	NB	NS	ON	PEI & NL	QC	SK
I	J01CR	Combinations of penicillins incl ß-lactamase inhibitors	0.70	0.57	0.56	0.61	0.80	0.47	1.56	0.78	0.47
	J01DD	Third-generation cephalosporins	0.05	0.07	0.05	0.07	0.11	0.08	0.17	0.04	0.02
	J01MA	Fluoroquinolones	2.18	1.84	2.12	2.41	1.89	2.32	4.21	2.04	1.36
	J01XA	Glycopeptides	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
	J01XD	Imidazole	0.27	0.25	0.33	0.25	0.27	0.25	0.30	0.20	0.27
	J01XX08	Linezolid	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
II	J01CA	Penicillins with extended spectrum	6.06	4.63	7.27	5.41	5.46	5.56	8.32	2.76	7.05
	J01CE	ß-lactamase sensitive penicillins	0.70	0.61	0.70	0.82	0.72	0.43	0.73	0.62	0.51
	J01CF	ß-lactamase resistant penicillins	0.21	0.26	0.66	0.20	0.33	0.22	0.54	0.19	0.44
	J01DB	First-generation cephalosporins	1.37	1.33	1.41	1.36	1.13	0.97	1.75	0.41	2.17
	J01DC	Second-generation cephalosporins	0.81	0.71	0.61	1.69	1.25	1.00	1.08	0.84	0.47
	J01EE	Combinations of sulfonamides and trimethoprim, incl. derivatives	1.21	1.09	1.29	1.28	1.22	0.79	1.91	0.44	1.48
	J01FA	Macrolides	4.10	3.65	3.58	4.89	3.73	3.96	5.17	3.38	3.28
	J01FF	Lincosamides	0.46	0.37	0.35	0.41	0.37	0.34	0.23	0.34	0.46
	J01GB	Aminoglycosides						<0.01			
	J01MB	Other quinolones			<0.01	<0.01	<0.01	<0.01		<0.01	
	J01RA	Sulfonamide combinations (excl. trimethoprim)	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.02	<0.01	0.01
	J01XC	Steroid antibacterials	<0.01	<0.01		<0.01	<0.01	<0.01		<0.01	<0.01
III	J01AA	Tetracyclines	3.12	3.10	3.12	2.04	2.87	2.28	2.42	1.63	4.28
	J01EB	Short-acting sulfonamides						<0.01		<0.01	
	J01EC	Intermediate-acting sulfonamides	<0.01	<0.01	<0.01			<0.01		<0.01	
	J01XE	Nitrofuran derivatives	0.57	0.56	0.41	0.76	0.87	0.70	0.46	0.27	1.01
	J01XX	Fosfomycin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NC	J01EA	Trimethoprim and derivatives	0.04	0.05	0.02	0.06	0.02	0.07	0.06	0.07	0.11
	J01XX05	Methenamine	0.01	0.02	<0.01	0.02	0.01	0.01	0.01	0.01	0.02
	J01	**Total**	**21.86**	**19.15**	**22.47**	**22.30**	**21.06**	**19.46**	**28.91**	**14.03**	**23.42**

Note: Roman numerals I-III indicate the categorization of antimicrobials based on their importance in human medicineas outlined by the Veterinary Drugs Directorate. NC: Not classified.

Appendix C – Additional Information

C.1 Abbreviations

A2C	Resistance to amoxicillin-clavulanic acid, cefoxitin, and ceftiofur
A2C-AMP	Resistance to amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and ampicillin
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
AT	Atypical
ATC	Anatomical Therapeutic Chemical
BPW	Buffered Peptone Water
CAHI	Canadian Animal Health Institute
CCAR	Canadian Committee on Antibiotic Resistance
CBA	Columbia Blood Agar
CCS	Canadian CompuScript
CFEZID	Centre for Foodborne, Environmental Zoonotic Infectious Diseases
CFIA	Canadian Food Inspection Agency
CIPARS	Canadian Integrated Program for Antimicrobial Resistance Surveillance
CLSI	Clinical and Laboratory Standards Institute
CPS	Compendium of Pharmaceuticals and Specialties
DANMAP	Danish Integrated Antimicrobial Resistance Monitoring and Research Program
DDD	Defined Daily Dose
DPA	Difco Phage Agar
DPB	Difco Phage Broth
EC	*Escherichia coli*
EMB	Eosin Methylene Blue
EnterNet	European Surveillance Network
ESAC	European Surveillance of Antimicrobial Consumption
EUCAST	European Committee on Antimicrobial Susceptibility Testing
GSS-EQAS	**G**lobal Salm-Surv-External Quality Assurance System
HACCP	Hazard Analysis Critical Control Point
ICEPT	International Centre for Enteric Phage Typing
IMS HEALTH	Intercontinental Medical Statistics
ISO	International Standards Organization
LB	Luria-Bertani agar
LFZ	Laboratory for Foodborne Zoonoses
MAC	MacConkey agar
mCCDA	Modified cefoperazone charcoal deoxycholate agar
MHA	Mueller Hinton Agar
MHB	Mueller Hinton Broth
MIC	Minimum Inhibitory Concentration
MSRV	Modified Semi-Solid Rappaport Vassiliadis
NA	Not available
N/A	Not applicable
NARMS	National Antimicrobial Resistance Monitoring System
NCCLS	National Committee on Clinical Laboratory Standards
NC	Not classified
NESP	National Enterics Surveillance Program
NML	National Microbiology Laboratory
NNDRS	National Notifiable Disease Reporting System
NSCARE	National Steering Committee for Antimicrobial Resistance Surveillance in Enterics
NT	Not tested
OIÉ	Organisation mondiale de la Santé Animale
PFGE	Pulse Field Gel Electrophoresis
PHAC	Public Health Agency of Canada
PICRA	Programme Intégré Canadien de Surveillance de la Résistance aux Antimicrobiens
PPHL	Provincial Public Health Laboratory
PT	Phage type
RFLP	Restriction fragment length polymorphism
Stat. Can	Statistics Canada
STL	*Salmonella* Typing Laboratory
TSA	Trypticase Soy Agar
TSI	Triple Sugar Iron
USA	United States of America
UT	Untypable
VDD	Veterinary Drugs Directorate
WHO	World Health Organization

Antimicrobial Abbreviations[1]

AMC	amoxicillin-clavulanic acid
AMK	amikacin
AMP	ampicillin
AZM	azithromycin
BAC	bacitracin
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
SXT	trimethoprim-sulfamethoxazole
STR	streptomycin
TET	tetracycline
TIG	tigecycline
TIO	ceftiofur
TYL	tylosin
VAN	vancomycin
TEL	telithromycin

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 although we use the term 'antimicrobial' to refer only to drugs effective against bacteria.

Antimicrobial resistance (AMR) is observed when the minimum inhibitory concentration value of an antimicrobial is equal to or above its resistance breakpoint. Resistant bacteria are able to withstand the effects of an antimicrobial drug using principally one of these four mechanisms: 1) drug inactivation or modification by enzyme production, 2) adaptation of its metabolism, 3) structural modification of antimicrobial targets and, 4) mechanisms to decrease drug permeability or increase drug elimination. Moreover, some bacteria display natural (or intrinsic) resistance to certain antimicrobials.

Co-resistance of genes or mutation in the same strain, each conferring resistance to a different class of drug. Also designated "associated resistance" (Aarestrup et al., 2006).

Cross-resistance Situation in which resistance to one drug is associated with resistance to another drug and due to a single biochemical mechanism (Aarestrup et al., 2006). For more details see 2005 CIPARS Annual Report, Appendix C.3.

[1] Antimicrobial abbreviations are from WHONET.

Defined Daily Dose (DDD) Statistical measure of drug consumption developed by the World Health Organization (WHO) used to standardise the comparative usage of various drugs between themselves or between different healthcare environments independently of cost or drug formulation.

Intermediate susceptibility is observed when the MIC value is between the resistance and the susceptibility break points (reference: CLSI M100-S16).

Minimum Inhibitory Concentration (MIC) Lowest antimicrobial drug concentration required to inhibit bacterial growth after an overnight in vitro incubation. MIC is used to confirm or monitor bacterial resistance. Resistance is observed when the MIC is higher than the defined breakpoint of resistance associated with each bacterial isolate.

Multidrug resistance (multiple drug resistance) is considered through the CIPARS report to designate the phenotypes that display resistance to more than one structurally-unrelated class of antimicrobials regardless of the resistance mechanisms involved. This can be resulting from cross-resistance and/or co-resistance mechanisms. For more details see 2005 CIPARS Annual Report, Appendix C.3.

Reduced susceptibility In this report, designates ciprofloxacin MICs from 0.125 to 2 ug/mL.

C.3 Demographic Information

Human Demographic Information

Table 68. Population demographics and health care availability.

Province	Post-censal population estimates Jan.1, 2005[1]	Post-censal population estimates Jan. 1, 2006[1]	Percentage change in 2006	Population density/Km (2005)[2]	Health Care - summary of discharges (2005-2006)[3]	Number of physicians/ 100,000 habitants (2005)[4]
Canada	**32,107,043**	**32,422,919**	**0.98%**	**3.57**	**3,235,836**	**169**
British Columbia	4,225,623	4,279,462	1.27%	4.63	735,611	199
Alberta	3,226,301	3,306,359	2.48%	5.15	360,006	188
Saskatchewan	994,687	990,930	-0.38%	1.67	241,596	156
Manitoba	1,174,959	1,178,348	0.29%	2.13	228,044	179
Ontario	12,462,445	12,599,364	1.10%	13.73	1,151,882	176
Québec	7,573,726	7,623,870	0.66%	5.58	NA	215
New Brunswick	752,266	751,111	-0.15%	10.51	152,552	172
Nova Scotia	938,339	936,988	-0.14%	17.57	192,844	218
Prince Edward Island	137,771	138,157	0.28%	24.41	28,172	144
Newfoundland and Labrador	517,339	514,409	-0.57%	1.38	128,468	193
Yukon Territory	30,862	31,150	0.93%	0.07	4,831	205
Northwest Territories	43,015	42,526	-1.14%	0.36	9,302	103
Nunavut	29,710	30,245	1.80%	0.02	2,528	46

[1] Statistics Canada - The Daily. (2006). Demographics statistics - Canada's Population, http://www.statcan.ca/Daily/English/060629/d060629d.htm, Accessed October 2007.

[2] Population density per square kilometre in 2006 was calculated based on the population on January 1, 2006 and the land area in square kilometres reported in Statistics Canada, Census of Population Products (2005). http://www40.statcan.ca/l01/cst01/phys01.htm, Accessed October 2007.

[3] Canadian Institute for Health Information. http://secure.cihi.ca/cihiweb/en/downloads/Data_Quality_Documentation_Discharge_Abstract_Database_Executive_Summary_2005-2006_e.pdf, Accessed October 2007.

[4] Canadian Institute for Health Information. http://secure.cihi.ca/cihiweb/en/smdb_figure_6_2005_e.html, Accessed October 2007.

Animal Demographic Information

Table 69. Canadian livestock-demographics, production, and per-capita consumption.

Farmed Species	Number of farms in 2006	Number of animals Jan.1, 2005	Number of animals Jan.1 2006	Percentage change in 2006 [(2006-2005)/2005]*100	Product produced in 2006[a] (metric tonnes)	Per-capita consumption in 2006 [10 b] (kg/person)
Cattle	**109,901** [1]	**14,925,000** [5]	**14,655,000** [5]	**-1.81%**	**135,314,000** [5]	**beef = 31.74**
beef cows	83,000	5,283,600	5,247,200	-0.69%	calves = 38,030	veal = 1.07
dairy cows	17,515	1,041,400	1,019,100	-2.14%		fluid milk = 83.39 litres
heifers (≥1year)	72,929					cream = 8.58 litres
heifers for beef replacement	45,407	637,800	628,300	-1.49%		cheese = 12.11
heifers for dairy replacement	16,585	517,800	495,100	-4.38%		
heifers for slaughter or feeding	23,998	945,000	986,800	4.42%		
steers (≥1year)	36,695	1,159,500	1,146,800	-1.10%		
calves (<1 year)	98,107	5,067,300	4,867,700	-3.94%		
bulls (≥1year)	71,958	272,600	264,000	-3.15%		
Swine	**11,497** [2]	**14,810,000** [6]	**15,110,000** [6]	**2.03%**	**1,898,296** [6]	**pork = 23.33**
sows and bred gilts	5,831	1,597,100	1,570,600	-1.66%		
boars	5,133	36,500	34,700	-4.93%		
Nursing and weaner pigs	5,560					
Grower and finishing pigs	8,937					
pigs < 20Kg		4,487,000	4,475,800	-0.25%		
pigs 20-60Kg		4,412,800	4,623,000	4.76%		
pigs>60Kg		4,276,600	4,405,900	3.02%		
Poultry		**646,743,000** [7]	**642,897,000** [7]	**-0.59%**	**1,160,139** [7]	**poultry = 37.72 / eggs = 10.60**
hens and chickens	22,712[3]	626,251,000	621,725,000	-0.72%	chickens = 996,728	chickens = 31.76
broilers, roasters, cornish hens	8,831					stewing hens = 1.52
turkeys	3,174	20,492,000	21,171,000	-3.31%	turkeys = 163,411	turkey = 4.44
Ovine	**11,031**[4]	**977,600** [8]	**893,800** [8]	**-8.57%**	**16,978** [8]	**sheep = 1.21**
ewes	10,309	606,200	563,200	-7.09%		
rams	8,175	26,600	25,700	-3.38%		
lambs	9,117					
replacement lambs		93,900	87,100	-7.24%		
market lambs		250,900	217,800	-13.19%		
Fish					salmon = 118,058 [9]	**total fish= 9.36**
salmon					trout = 5,033	fresh & frozen seafish = 4.09
trout					finfish = 9,171	processed seafish = 2.87
steelhead					shellfish = 38,676	shellfish = 1.89

[1] Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95-629-XIE/1/1.24.htm, Accessed October 2007.

[2] Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95-629-XIE/1/1.25.htm, Accessed October 2007.

[3] Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95-629-XIE/1/1.29.htm, Accessed October 2007.

[4] Statistics Canada, Census of Agriculture. http://www.statcan.ca/english/freepub/95-629-XIE/1/1.26.htm, Accessed October 2007.

[5] Statistics Canada, Census of Agriculture. Cattle Statistics 2007. Cat. No. 23-012-XIE, Vol 6. No.2. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2007001.pdf, Accessed October 2007.

[6] Statistics Canada, Census of Agriculture. Hog Statistics 2007. Cat. No. 23-010-XIE, Vol. 6 No.3. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2007004.pdf, Accessed October 2007.

[7] Statistics Canada, Census of Agriculture. Poultry and Egg Statistics 2007. Cat. No. 23-015-XIE, Vol.4 No.2. http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2007001.pdf, Accessed October 2007.

[8] Statistics Canada, Census of Agriculture. Sheep Statistics 2007. Cat. No. 23-011-XIE, Vol. 6 No.2. http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2007001.pdf, Accessed October 2007.

[9] Statistics Canada, Aquaculture Statistics 2006. Cat. No. 23-222-X. http://www.statcan.ca/english/freepub/23-222-XIE/23-222-XIE2006000.pdf

[10] Statistics Canada, Food Statistics. Cat. No. 21-020-XIE. http://www.statcan.ca/english/freepub/21-020-XIE/21-020-XIE2006001.pdf

[a] Total cold dressed weight not including edible offal.

[b] Food available for consumption (eviscerated).

Note: Statistics from the 2005 CIPARS report are slightly different than those reported here. These changes were made to reflect updates in the 2006 Census of Agriculture report.

Table 70. The number of births, slaughtered animals, international imports and exports and on-farm deaths of Canadian cattle, swine, and ovine in 2006.

	Cattle [1]	Swine [2]	Ovine [3]
Births	5,313,100	35,432,400	870,000
Slaughter	3,962,300	21,785,900[b]	768,400
% change of slaughter in 2006 [a]	-9.61%	-2.39%	-5.43%
International imports	38,000	600	15,900
% change of imports in 2006 [a]	80.09%	-25.00%	15800.00%
International exports	1,031,900	8,777,000	3,200
% change of exports in 2006 [a]	84.63%	6.84%	255.56%
Deaths and condemnations	881,900	1,915,000	129,000
% change of deaths and condemnations in 2006 [a]	3.77%	-12.38%	-4.16%

[1] Statistics Canada, Census of Agriculture. Cattle Statistics 2007. Cat. No.23-012-XIE, Vol 6. No.2. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2007001.pdf, Accessed October 2007.

[2] tatistics Canada, Census of Agriculture. Hog Statistics 2007. Cat. No. 23-010-XIE, Vol. 6 No.3. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2007004.pdf, Accessed October 2007.

[3] Statistics Canada, Census of Agriculture. Sheep Statistics 2007. Cat. No. 23-011-XIE, Vol. 6 No.2. http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2007001.pdf, Accessed October 2007.

[a] Percent change was calculated by [(2006-2005)/2005]x100

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

Table 71. Veterinary services in Canada; *Canadian Veterinary Medical Association*, 2006.

Province	Total number of veterinary practices 2006	Total number of large animal practices 2006
British Columbia	439	40
Alberta	330	39
Saskatchewan	117	15
Manitoba	105	8
Ontario	1108	112
Québec	503	97
New Brunswick	54	2
Nova Scotia	73	3
Prince Edward Island	13	0
Newfoundland and Labrador	14	0
Yukon Territory	3	0

Source: Email correspondence. November 2007 with Canadian Veterinary Medical Association.

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