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CANADIAN INTEGRATED PROGRAM FOR ANTIMICROBIAL RESISTANCE SURVEILLANCE (CIPARS)

ANNUAL REPORT



Canada

TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP,
PARTNERSHIP, INNOVATION AND ACTION IN PUBLIC HEALTH.

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2015

**CANADIAN INTEGRATED
PROGRAM FOR ANTIMICROBIAL
RESISTANCE SURVEILLANCE
(CIPARS)**

ANNUAL REPORT



ANNUAL REPORT 2015

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EXECUTIVE SUMMARY

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) collects, analyses, and communicates trends in antimicrobial use and in antimicrobial resistance for select bacteria from humans, animals, and retail meat across Canada. The bacteria under surveillance are known as enteric bacteria (they can be found in the intestines of people and animals) and can be transmitted between animals and people. Information from CIPARS supports measures to contain the emergence and spread of resistant bacteria among animals, food, and people, with the aim of prolonging the effectiveness of antimicrobials.

Generalizing across all animal species in Canada, antimicrobial use in animals increased in 2015. Data provided by the Canadian Animal Health Institute (CAHI) indicated that the total quantity of antimicrobials distributed for use in animals and the total quantity of medically important antimicrobials adjusted for animal biomass were the highest reported since surveillance began in 2006. In comparison with antimicrobial use in people, 1.7 times more antimicrobials were distributed for sale for use in animals than for use in people. In this comparison, only medically important antimicrobials were considered (which means that ionophores and chemical coccidiostats used in animals were excluded), Canadian standard weights of animals were applied and the most recent animal (2015) and human (2014) data were used. Antimicrobial use data from CAHI, broiler chicken and grower-finisher pig sentinel farms, and humans showed that the types of antimicrobials used differed substantially between people and animals and between different animal species. This finding highlights the critical importance of collecting surveillance data from different host species. Based on antimicrobial use data collected from sentinel farms in 2015, the majority of antimicrobial use reported on broiler chicken and grower-finisher pig farms was for the purpose of disease prevention, rather than for treatment of disease or growth promotion.

Farm-level antimicrobial use and resistance surveillance indicated that a change in antimicrobial use policy on broiler chicken farms across Canada appears to be having the desired goal of reducing use of critically important antimicrobials, in particular the use of the antimicrobial ceftiofur (a 3rd generation cephalosporin). Decreases in ceftriaxone resistance (ceftriaxone is analogous to ceftiofur) in both *Salmonella* and *E. coli* in several stages along the food chain was also apparent.

In terms of other antimicrobial resistance findings, the frequency of fluoroquinolone resistance in *Campylobacter* from chicken appeared to be fluctuating at the regional level and changing over time. CIPARS has limited access to data on fluoroquinolone resistance in *Campylobacter* from humans, hence there is limited ability to make comparisons between what is happening in animals and people. In 2015, resistance to ciprofloxacin (a fluoroquinolone) was observed in *S. Kentucky* isolates from food animal isolates for the first time. It was also the first time resistance to ciprofloxacin was ever observed in any *Salmonella*

serovar recovered from chicken. Since 2011, multidrug resistance appears to be rising among cattle *Salmonella* clinical isolates with a number of isolates exhibiting resistance to more than 5 antimicrobial classes.

CIPARS continues to evolve to meet stakeholder and program needs. In addition to core surveillance activities, CIPARS continues to explore new means to describe emerging issues and report integrated data across various host species, bacterial species and regions. CIPARS has returned to the release of a single annual report to be posted on the government of Canada website. Key 2015 and 2016 CIPARS findings will be incorporated into the 2017 Canadian Antimicrobial Resistance Surveillance System Report.



CONTRIBUTORS TO CIPARS

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- *Abattoir Surveillance*: Anne Deckert
- *Farm Surveillance*: Agnes Agunos, Anne Deckert, Sheryl Gow, and David Léger
- *Surveillance of Animal Clinical Isolates*: Jane Parmley
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National Microbiology Laboratory @ Winnipeg

- Reference Services Unit: Sara Christianson
- Antimicrobial Susceptibility Testing: Michael Mulvey

PROVINCIAL PUBLIC HEALTH LABORATORIES

We gratefully acknowledge the provincial public health laboratories for their longstanding support and for providing data and bacterial isolates for CIPARS:

- British Columbia Public Health Microbiology and Reference Laboratory, Provincial Health Services Authority, British Columbia (Linda Hoang)
- Provincial Laboratory for Public Health, Alberta (Marie Louie)
- Saskatchewan Laboratory and Disease Control Services (Greg Horsman)
- Cadham Provincial Laboratory, Manitoba (John Wylie)
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- Newfoundland Public Health Laboratory (George Zahariadis)

³ In 2015, the National Microbiology Laboratory and the Laboratory for Foodborne Zoonoses were combined into a single laboratory, the National Microbiology Laboratory with multiple campuses.

RETAIL MEAT SURVEILLANCE

We would like to extend our thanks to the following organizations for their participation in CIPARS *Retail Meat Surveillance*:

- Centre for Coastal Health (Carl Ribble, Stefan Iwasawa)
- Agriculture and Agri-Food Canada (Mueen Aslam, Tineke Jones, Cara Service, Tim McAllister)
- University of Prince Edward Island, Atlantic Veterinary College (J.T. McClure, Carol McClure, Matthew Saab, Cynthia Mitchell, and Anne Muckle)

We also thank the following health unit managers, public health inspectors, and environmental health officers: Bob Bell, Tanya Musgrave, Torsten Schulz, and Lee Siewerda.

ABATTOIR SURVEILLANCE

We would like to thank the abattoir operators and the Canadian Food Inspection Agency's regional directors, inspection managers, and on-site staff, for their extensive voluntary participation in CIPARS *Abattoir Surveillance*.

FARM SURVEILLANCE

We are grateful for the support of the Alberta Agriculture and Forestry and the Saskatchewan Ministry of Agriculture, as well as the sentinel veterinarians and the producers who participated in *Farm Surveillance* by providing data and enabling collection of samples for bacterial culture.

We would like to acknowledge the following organizations for their contribution to the CIPARS *Farm Surveillance* components:

- Alberta Chicken Producers
- British Columbia Chicken Marketing Board
- Canadian Hatcheries Federation
- Canadian Pork Council and Provincial Pork Boards
- Canadian Poultry and Egg Processors Council
- Chicken Farmers of Canada
- Chicken Farmers of Ontario
- CIPARS Farm Broiler Chicken Industry Antimicrobial Use/Resistance Working Group
- CIPARS Farm Swine Advisory Committees
- Les Éleveurs de volailles du Québec

PROVINCIAL ANIMAL HEALTH LABORATORIES

We gratefully acknowledge the provincial animal health laboratories for their longstanding support and for providing data and bacterial isolates for CIPARS:

- Animal Health Centre, British Columbia Ministry of Agriculture (Nancy DeWith and Erin Zabek)
- Government of Alberta, Agriculture and Forestry (Rashed Cassis)
- Saskatchewan Health, Saskatchewan (Paul Levett)
- Veterinary Services Branch Laboratory, Manitoba (Neil Pople)
- The Animal Health Laboratory, University of Guelph, Ontario (Durda Slavic)
- IDEXX Laboratories, Ontario (Hani Dick)
- Direction générale des laboratoires d'expertise du ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (Marie Nadeau)
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- Provincial Veterinary Laboratory, Department of Agriculture, Fisheries, and Aquaculture, New Brunswick (Jim Goltz)
- Veterinary Pathology Laboratory, Nova Scotia (Grant J. Spearman)
- Diagnostic Services, Atlantic Veterinary College, Prince Edward Island (Jan Giles)
- Animal Health Laboratory, Department of Fisheries, Forestry and Agrifoods, Newfoundland and Labrador (Laura Rogers)

QUANTITIES OF ANTIMICROBIALS DISTRIBUTED FOR SALE FOR USE IN ANIMALS

We would like to sincerely thank the Canadian Animal Health Institute (CAHI), its President Jean Szkotnicki and their member companies for voluntarily providing the quantities of antimicrobials distributed for sale for use in animals in Canada. We would also like to thank Impact Vet (Jim White) for collecting and collating the data and providing many ideas for reporting format, at the request of (CAHI).

CIPARS would like to thank the small group of volunteer industry and provincial representatives who have participated in active discussions on appropriate denominators for quantities of antimicrobials distributed for use in animals, including very recent discussions with Dr. Brian Radke. CIPARS would also like to thank the University of Guelph (Dr. Scott McEwen) for the joint collaborations with multiple students who have assisted in the preparation of the population correction unit: Ashley Gagne, Victoria Wells, Sarah Garner, Dr. Angela Bosman, and Dr. Daleen Loest.

CIPARS thanks the European Surveillance for Veterinary Antimicrobial Consumption, the Food and Drug Administration's Center for Veterinary Medicine of the United States, and the World Organization for Animal Health (OIE) for many long discussions on appropriate denominators for antimicrobial sales/distribution data.

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

OTHER PARTICIPANTS

We gratefully acknowledge the efforts of field workers, laboratory technicians, and data managers for their contributions. The careful collection of samples, processing of isolates, and recording of results are essential to the ongoing success of CIPARS.

We are grateful to the National Antimicrobial Resistance Monitoring System of the United States for sharing information and facilitating harmonization with CIPARS.

We would also like to thank the following individuals and organizations for their contribution to CIPARS in 2015:

Public Health Agency of Canada

Ashleigh Andrysiak, Louise Bellai, Mark Blenkinsop, Louise Beausoleil, Gail Christie, Sindy Cleary, Ann-Marie Cochrane, Marie-Claude Deshaies, Logan Flockhart, George Golding, Dolly Kambo, Nicol Janecko, Bernard Jackson, Jasmina Kircanski, Ora Kendall, Lisa Landry, Stacie Langner, Julie Légaré, Laura Martin, Sarah Martz, Ryan McKarron, Ketna Mistry, Ali Moterassed, Manuel Navas, Linda Nedd-Gbedemah, Derek Ozunk, Ann Perets, Frank Pollari, Susan Read, Julie Roy, Sophia Sheriff, Lien Mi Tien, Carol Tinga, Anatoliy Trokhymchuk, Rama Viswanathan, Victoria Weaver, and Betty Wilkie.

We are grateful for the student support for antimicrobial use metrics development and assistance with the denominator data: Angelina Bosman, Jeanette Cooper, Daleen Loest, Maggie McCann, and Courtney Primeau.

Canadian Food Inspection Agency

Daniel Leclair, Blaise Ouattara, and Marina Steele

Health Canada, Veterinary Drugs Directorate

Xian-Zhi Li and Manisha Mehrotra

Health Canada, Pest Management Regulatory Agency

Brian Belliveau

Canadian Meat Council

Independent contractors

John Ranson and Ron Templeman

*To the memory of our dear friend and colleague,
Bernard Jackson*

*He was an instrumental part of our CIPARS team and his
warm smile, kindness, great ideas and knowledge will be
sorrowfully missed.*

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PROGRAM OVERVIEW

ABOUT CIPARS

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

CIPARS continues to evolve to meet stakeholder needs. To enhance the timeliness of reporting, between 2012 and 2014 CIPARS piloted the division of the annual report into separate chapters, with chapters being posted as they were completed. This reporting method did not result in efficiency and CIPARS has returned to the release of a single Annual Report. For 2015, integrated findings will be published in the upcoming 2017 Canadian Antimicrobial Resistance Surveillance System Report.

CIPARS OBJECTIVES

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

WHAT'S NEW

ANTIMICROBIAL RESISTANCE

- Minimum Inhibitory Concentration (MIC) tables will no longer appear in the annual report; however, they are available upon request.
- There was no retail sampling conducted in the Atlantic region in 2015 due to budgetary constraints. Additionally, only a partial year's worth of retail sampling was conducted in Ontario due to unavailability of sampling technician staff.

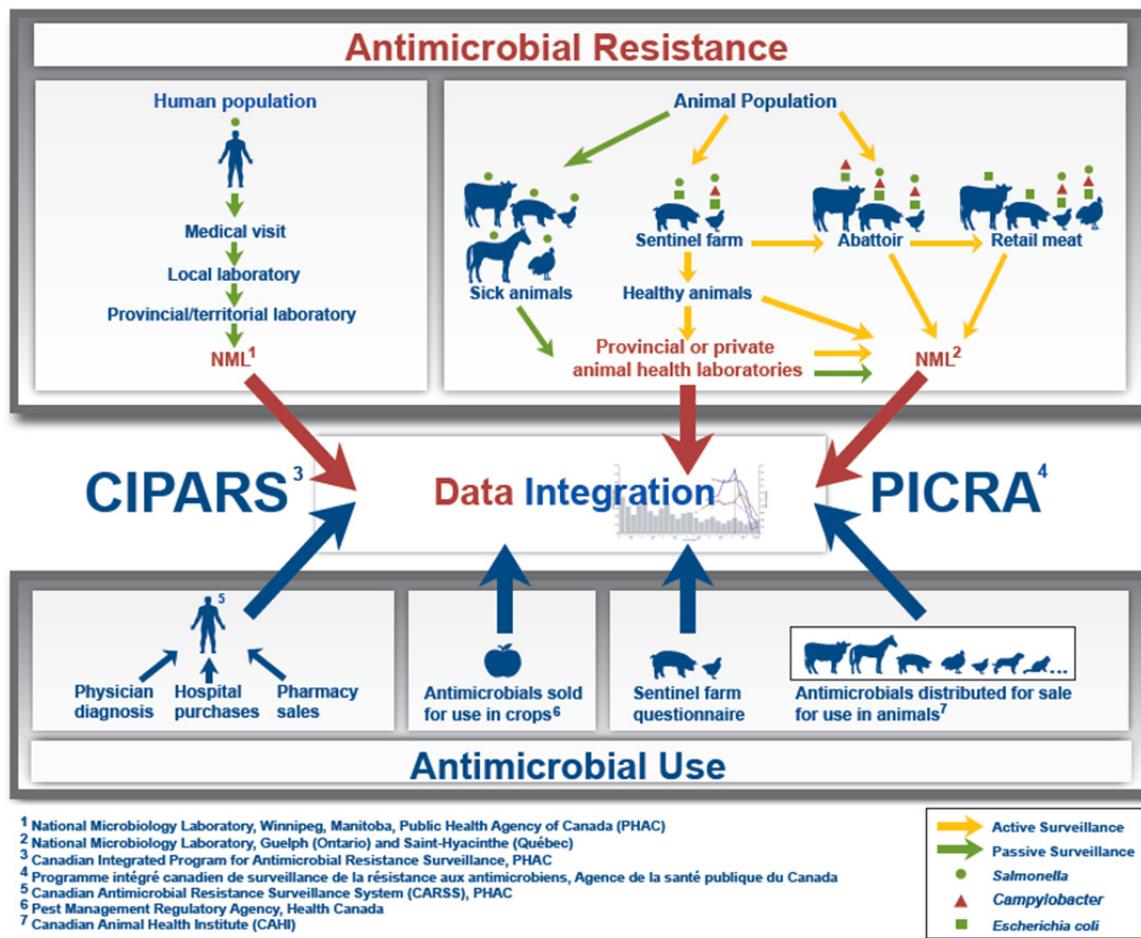
ANTIMICROBIAL USE IN ANIMALS

- In 2015, an additional quantitative antimicrobial use metrics, number of Canadian Defined Daily Doses for animals per 1,000 animal-days ($n\text{DDD}_{\text{vetCA}}/1,000 \text{ animal-days}$) applied to both the broiler chicken and grower-finisher pigs Farm Surveillance data.

CIPARS SURVEILLANCE COMPONENTS AND DATA

Surveillance components and data sources are assembled together for analysis and reporting as shown in Figure 1. Bringing together all of the data from all the various surveillance components requires organization and flexibility. A detailed description of data sources, information flow and points of integration, analysis and reporting are illustrated in Figure 5. 8.

Figure 1. Diagram of the CIPARS components, 2015



¹ National Microbiology Laboratory, Winnipeg, Manitoba, Public Health Agency of Canada (PHAC)

² National Microbiology Laboratory, Guelph (Ontario) and Saint-Hyacinthe (Québec)

³ Canadian Integrated Program for Antimicrobial Resistance Surveillance, PHAC

⁴ Programme intégré canadien de surveillance de la résistance aux antimicrobiens, Agence de la santé publique du Canada

⁵ Canadian Antimicrobial Resistance Surveillance System (CARSS), PHAC

⁶ Pest Management Regulatory Agency, Health Canada

⁷ Canadian Animal Health Institute (CAHI)

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CHAPTER 1—INTEGRATED FINDINGS AND DISCUSSION



HOW TO READ THIS CHAPTER

Integrated findings cross host species (human, chicken, pigs, beef cattle, and turkey), surveillance components [human, farm, abattoir (slaughterhouse), retail meat, and clinical animals], antimicrobial resistance and antimicrobial use, or a combination of these. The integrated findings included here were presented at the annual CIPARS stakeholder meeting on November 15, 2016. Where appropriate in this report, we have incorporated and addressed comments, suggestions and questions raised by the CIPARS stakeholder meeting participants.

Further details about the individual CIPARS components, regional and sector specific trends can be found in Chapter 2—Animal Health Status and Farm Information, Chapter 3—Antimicrobial Use in Animals, Chapter 4—Antimicrobial Resistance, and Chapter 5—Design and Methods.

Most of the data presented in this chapter are reported in other areas of this report, with the exception of kg of active ingredient of antimicrobials reported being used in humans and plants. Human antimicrobial use data were provided to CIPARS by the Canadian Antimicrobial Resistance Surveillance System and consist of quantities dispensed by community pharmacies and purchased by hospitals. The quantities of antimicrobials sold for use as pesticides on crops were provided by Health Canada's Pest Management Regulatory Agency. Where appropriate, additional data from CIPARS research projects (data not presented elsewhere in this annual report) were incorporated into the integrated findings.

In this chapter, the term "agri-food" is used to refer to all non-human CIPARS components.

The main focus of the antimicrobial resistance integration is on antimicrobials of very high importance to human medicine (Category I; Health Canada's Veterinary Drug Directorate and other select clinically important antimicrobials.

SUMMARY OF INTEGRATED FINDINGS AND DISCUSSION

ANTIMICROBIALS USE DIFFERED BETWEEN PEOPLE AND ANIMALS AND BETWEEN DIFFERENT ANIMAL SPECIES

- While many of the same antimicrobials are distributed and/or sold for use in both humans and animals, the relative amounts used differ between people and animals and between the different animal species.
 - Hence antimicrobial use in one species should not be generalized to another species.

THE MAJORITY OF ANTIMICROBIAL USE REPORTED ON BROILER CHICKEN AND GROWER-FINISHER PIG FARMS WAS USED FOR DISEASE PREVENTION

- Reduction in reported use for growth promotion purposes on broiler chicken farms is believed to be due to anticipatory changes by the industry ahead of expected federal regulatory changes.

A POULTRY INDUSTRY CHANGE IN USE POLICY APPEARED TO BE HAVING THE DESIRED GOAL OF REDUCING USE OF ANTIMICROBIALS OF VERY HIGH IMPORTANCE IN THIS SECTOR

- A poultry industry led intervention to remove use of Category I antimicrobials for disease prevention appeared effective in both reducing the use and resistance to these antimicrobials in 2015.

THE FREQUENCY OF FLUOROQUINOLONE RESISTANCE IN *CAMPYLOBACTER* FROM CHICKEN APPEARS TO BE CHANGING AT THE REGIONAL LEVEL BUT ONLY LIMITED DATA EXIST REGARDING FLUOROQUINOLONE-RESISTANT *CAMPYLOBACTER* FROM HUMANS

- There are ongoing regional differences in fluoroquinolone-resistant *Campylobacter*. In 2015, there were significant changes in the level of resistance observed in British Columbia and Ontario.
- Currently, the only data on resistant *Campylobacter* from humans is from British Columbia; CIPARS is working with FoodNet Canada and other collaborators to try and fill this data gap.

SINCE 2011, THE NUMBER OF ISOLATES RESISTANT TO MORE THAN 5 ANTIMICROBIAL CLASSES HAS BEEN INCREASING

- The frequency of highly resistant (greater than 5 antimicrobial classes) isolates may be increasing.

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INTEGRATED FINDINGS AND DISCUSSION

INTEGRATED ANTIMICROBIAL USE DATA

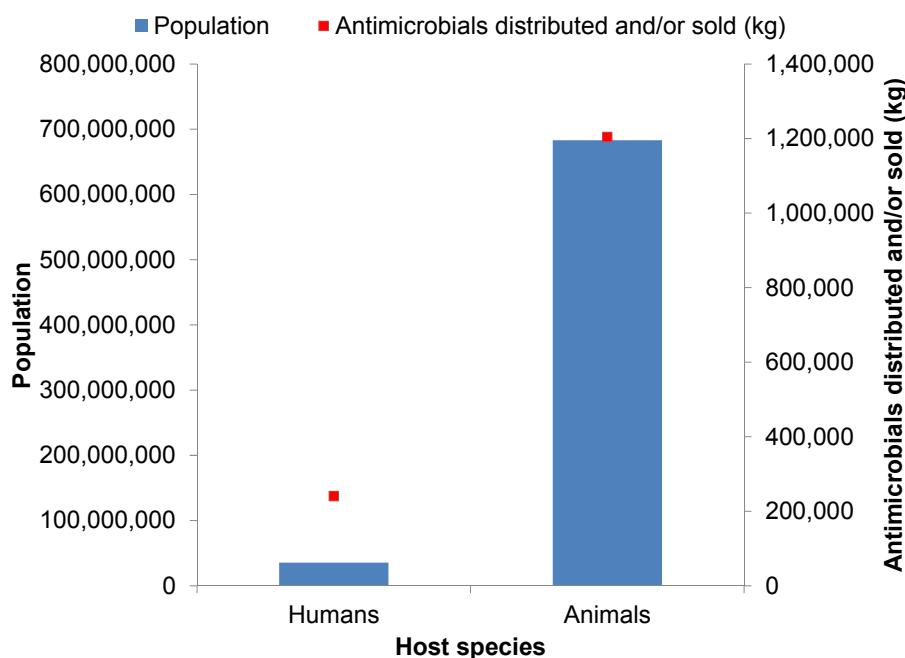
COMPARING HUMANS (2014 DATA), ANIMALS (2015 DATA), AND CROPS (2015 DATA)

Canada is a major producer of food animals. As such, there are roughly 19 times more animals than people in Canada (Figure 1. 1). However, this is an underestimate for the animal population because we were unable to include the numbers of farmed fish; statistics on fish are reported as kilograms produced and not as individual animals. At the time of writing, the 2015 data for the quantities of antimicrobials dispensed by community pharmacies or purchased by hospitals were not available.

When considering only medically important antimicrobials (Categories I, II and III), there are roughly 5 times more antimicrobials distributed for use in animals than sold for people (Figure 1. 1). The ionophores or chemical coccidiostats were not included in this calculation because these antimicrobials are not used in human medicine. These classes of antimicrobials represent 32% of the total kilograms of antimicrobials distributed for use in animals. If these classes are included in the comparisons, approximately 7 times more antimicrobials are distributed for use in animals than sold for people.

Because some animals are heavier than people and some are lighter it is not appropriate to directly compare only population numbers for the purpose of contextualizing antimicrobial sales data. Therefore, CIPARS applied an adjustment to the human and animal data to account for population numbers and weights of the animal/human hosts. Using European standard weights, the quantity of antimicrobials distributed/sold for use in animals was 1.9 times greater than the quantity distributed to people. When provisional Canadian animal weights were used for this calculation, the quantity distributed for use in animals was 1.6 times more than the quantity sold for use in people.

Figure 1. 1 Human and animal population estimates with total kilograms of antimicrobials distributed and/or sold, 2014 human sales data; 2015 animal distribution data

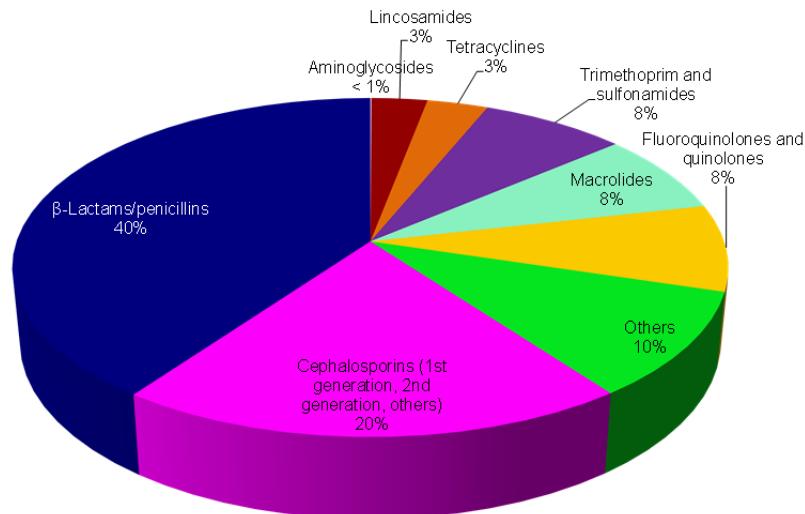


Data sources: Human pharmacy and hospital data from Quintiles IMS (formerly known as IMS Health) via the Canadian Antimicrobial Resistance Surveillance System (2014), Canadian Animal Health Institute (2015), Statistics Canada, Agriculture and Agri-food Canada, and Equestrian Canada (formerly known as Equine Canada). Ionophores and chemical coccidiostats were excluded.

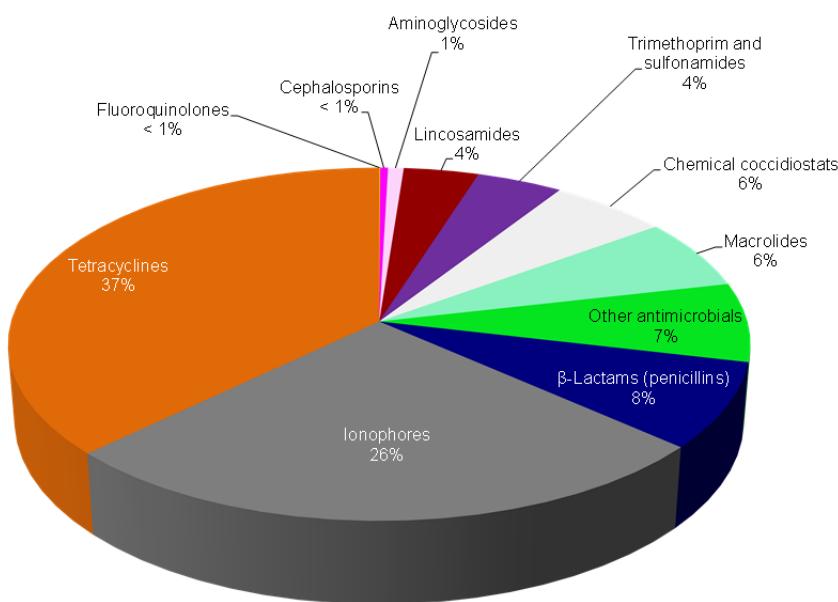
While the same or similar products may be licensed for use in people and animals, there are important differences in the relative quantity of antimicrobials distributed and/or sold in animals and people (Figure 1. 2). In people, the predominant classes (by kilograms of active ingredients) are β -lactams, cephalosporins, and "other antimicrobials". In animals, the predominant classes are tetracyclines, ionophores, and β -lactams.

Figure 1.2 Relative proportion of antimicrobials distributed and/or sold for use in humans and animals, based on active ingredients (kg)

a) Humans



b) Animals



Data sources: Human pharmacy and hospital data from Quintiles IMS (formerly known as IMS Health) via the Canadian Antimicrobial Resistance Surveillance System (2014), Canadian Animal Health Institute (2015).

"Other antimicrobials" for humans include bacitracin, chloramphenicol, colistin, daptomycin, ertapenem, fixadomycin, fosfomycin, fusidic acid, imipenem and cilastatin, linezolid, meropenem, methenamine hippurate, methenamine mandelate, metronidazole, nitrofurantoin, and vancomycin.

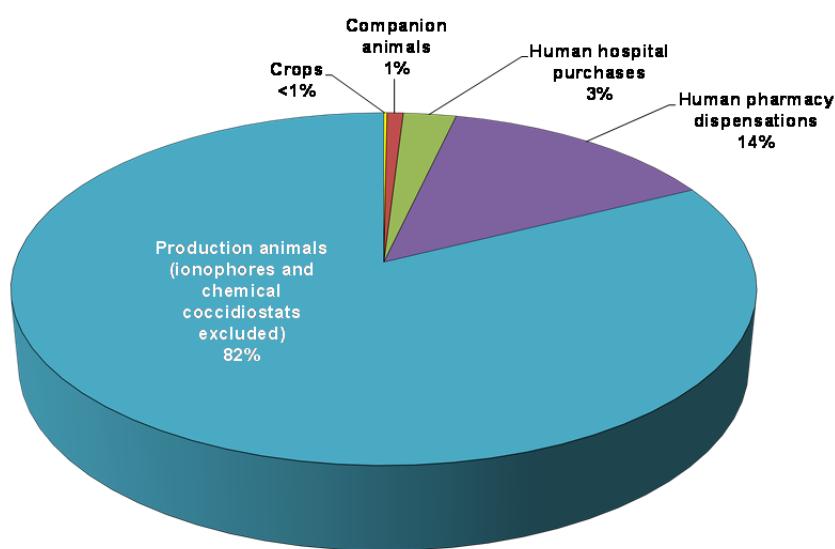
"Other antimicrobials" for animals include avilamycin, bacitracins, bambamycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

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The predominant sector to which antimicrobials were sold/distributed (measured in kilograms) was production animals (Figure 1. 3). When ionophores and chemical coccidiostats were excluded, 83% of the total antimicrobials were distributed for use in animals (companion animals plus production animals); when ionophores and chemical coccidiostats were included then 88% of the antimicrobials were intended for use in animals.

Animal distribution data currently do not account for quantities imported for own use or as active pharmaceutical ingredients for further compounding. As a result, the total kilograms of antimicrobials sold/distributed for use in animals were underestimated. The Canadian Animal Health Institute (CAHI) has estimated that for all animal pharmaceutical products, the loss of market share represented by own use importation or active pharmaceutical ingredient importation is roughly 13% (personal communication, CAHI). This estimate is for all animal health products, not just antimicrobials.

Figure 1. 3 Proportion of total kilograms of antimicrobials distributed and/or sold in Canada, by sector



Data source: Human pharmacy and hospital data from Quintiles IMS (formerly known as IMS Health) via the Canadian Antimicrobial Resistance Surveillance System (2014), CAHI (2015), and Health Canada's Pest Management Regulatory Agency.

Animal distribution data currently does not account for quantities imported for own use or as active pharmaceutical ingredients for further compounding; hence are underestimates of total quantities used.

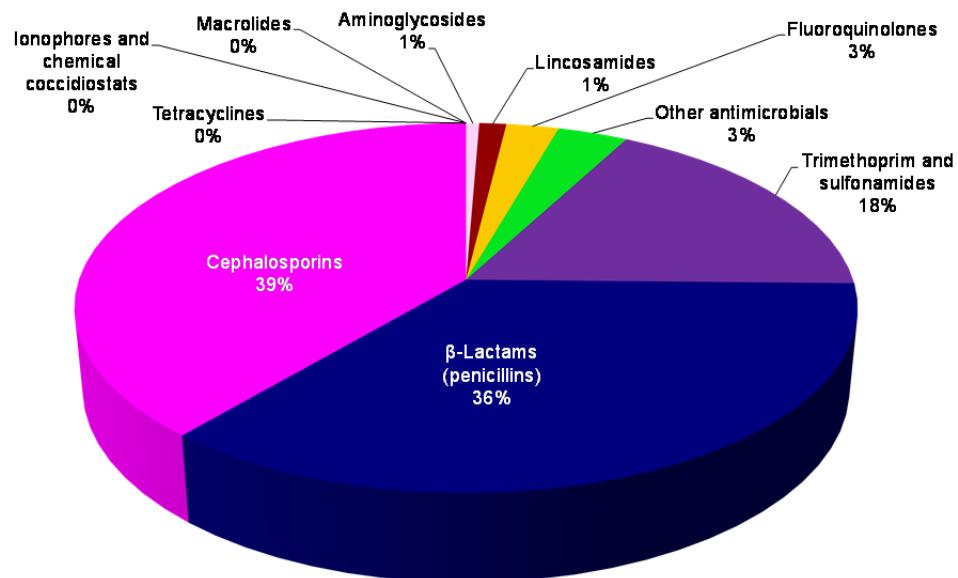
COMPARING ANTIMICROBIAL SALES DATA BETWEEN ANIMAL SECTORS

The predominant antimicrobial classes distributed for companion animals were very different than for production animals (Figure 1. 4). For production animals in 2015, the antimicrobials distributed for sale were mostly tetracyclines, ionophores and β -lactams (penicillins). Since 2014, the total quantity of antimicrobials distributed for use in production animals increased by 5%; the classes with the greatest relative increases were the fluoroquinolones and the tetracyclines; use of both classes increased by 10%.

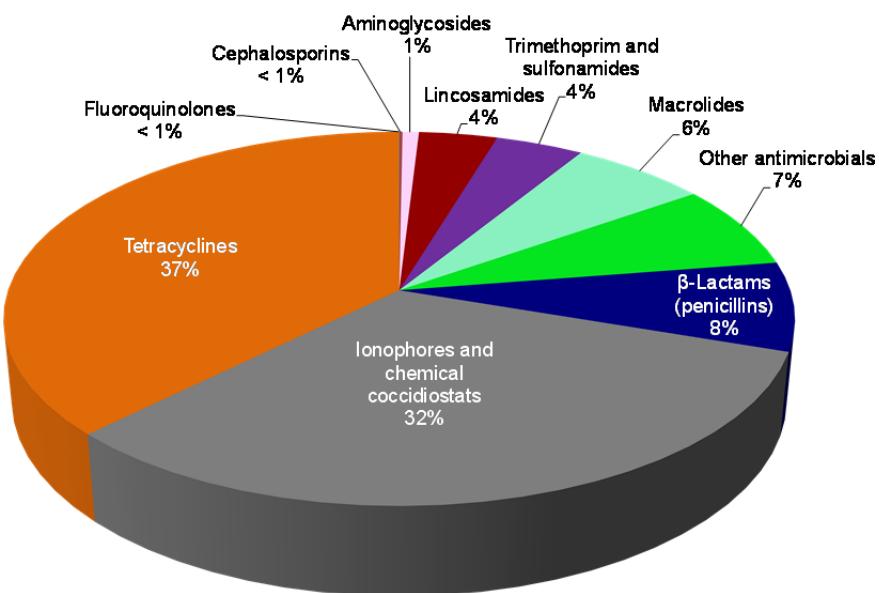
In contrast, antimicrobials distributed for sale for use in companion animals were mostly cephalosporins, β -lactams (penicillins), and trimethoprim and sulfonamides (Figure 1. 7). Since last year, the total quantity distributed for use in companion animals increased by 2%; antimicrobial classes with the greatest relative increases were the fluoroquinolones (10%), lincosamides (9%) and trimethoprim-sulfas (9%). It is important to note that for tetracyclines and macrolides all sales were attributed to use in production animals (livestock, poultry, and horses); there were no reported sales of these antimicrobials classes for use in companion animals.

Figure 1. 4 Relative proportions of antimicrobials distributed for use in companion and production animals, based on active ingredients (kg)

a) Companion animals



b) Production animals (including horses)



Data source: CAHI, 2015.

Antimicrobial sales were assigned to animal type according to label claim and in the situation where mixed species was indicated on the label, the manufacturer assigned the kg to either "Companion animal" or "Production animal".

Values do not include antimicrobials imported under the 'own use' provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

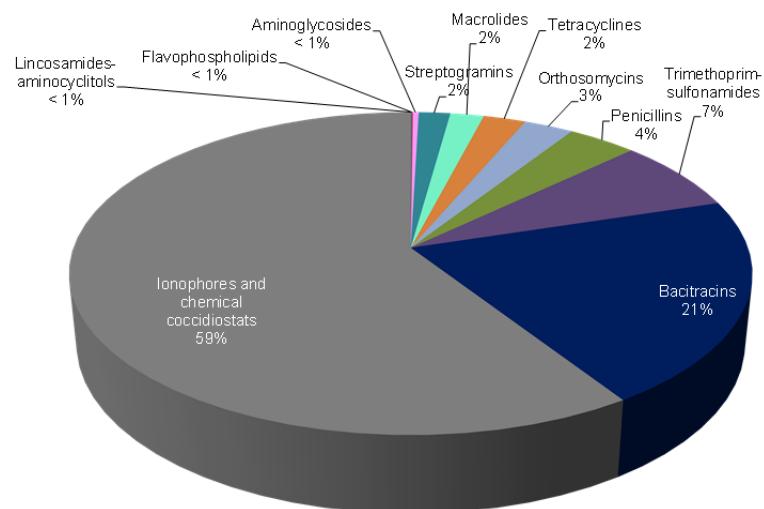
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COMPARING FARM ANTIMICROBIAL USE DATA OVER TIME AND BETWEEN ANIMAL SECTORS

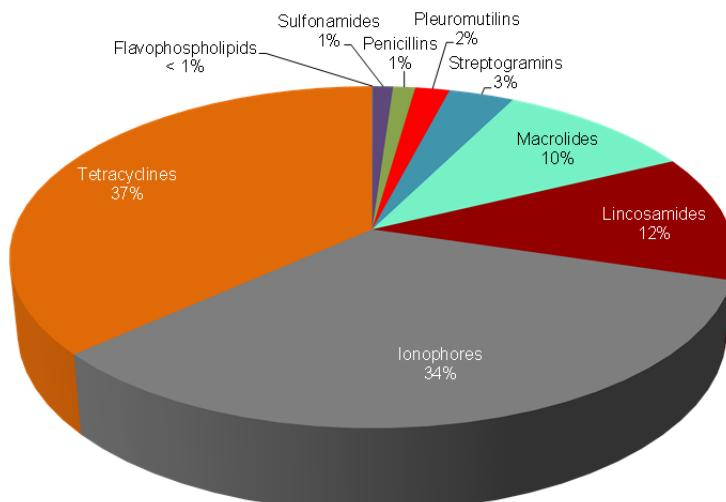
There are important differences in the types and relative quantities of antimicrobials reported for use between food animal species included in the *Farm Surveillance* program (Figure 1. 5). For broiler poultry (feed, water and injection), the predominant antimicrobial classes used in 2015 were ionophores and chemical coccidiostats, bacitracins, and trimethoprim-sulfonamides. Conversely, in grower-finisher pigs (feed only data) the predominant antimicrobial classes used were tetracyclines, ionophores, and lincosamides.

Figure 1. 5 Relative use of antimicrobial classes in feed, including ionophores and chemical coccidiostats, based on active ingredients (kg), in grower-finisher pigs and broiler chickens, adjusted for populations and weights, 2015

a) Broiler chickens



b) Grower-finisher pigs



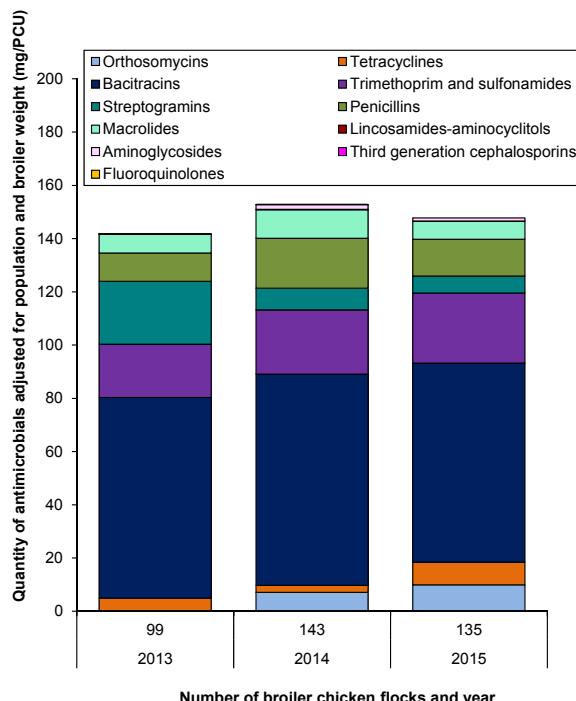
Data source: CIPARS (Farm), 2015.

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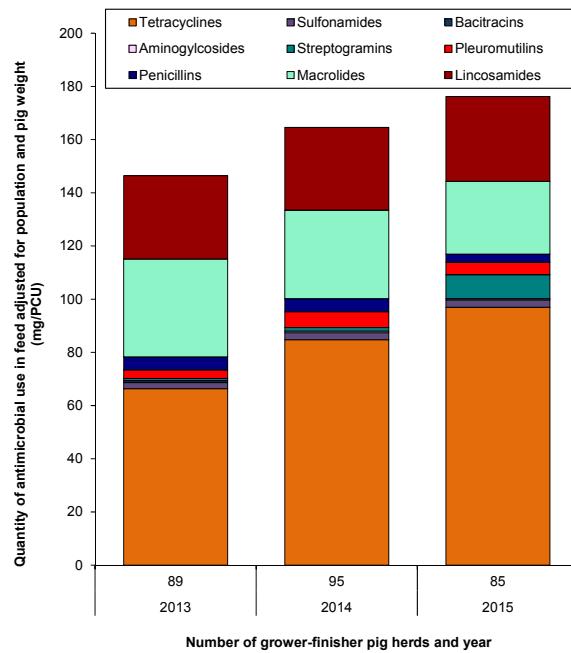
When ionophores and chemical coccidiostats were excluded from the analysis, the difference in drug classes used between broiler poultry and grower-finisher swine remained (Figure 1.6). Overtime, the CIPARS data indicated that in broiler poultry, total use by any route, corrected for animal population and weight, dropped in 2015 and most of the decline in use was in macrolides, penicillins, and bacitracins. Use of trimethoprim-sulfonamides, orthosomycins and tetracyclines in broiler poultry increased in 2015. Among grower-finisher swine herds, the total use in feed corrected for animal population and weight, increased in 2015. The largest increases in the quantities used were in tetracyclines and streptogramins; macrolide use decreased in 2015 (Figure 1.9).

Figure 1.6 Quantity of antimicrobial use, excluding ionophores and chemical coccidiostats, in grower-finisher pigs and broiler chickens, adjusted for populations and weights, 2013–2015

a) Broiler chickens



b) Grower-finisher pigs



Broiler chickens
Administration through feed,
water, and by injection

Grower-finisher pigs
Administration through feed only

Data source: CIPARS (Farm) 2013–2015.

mg/PCU = mg (total milligrams of active ingredient consumed by participating flock/herds) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

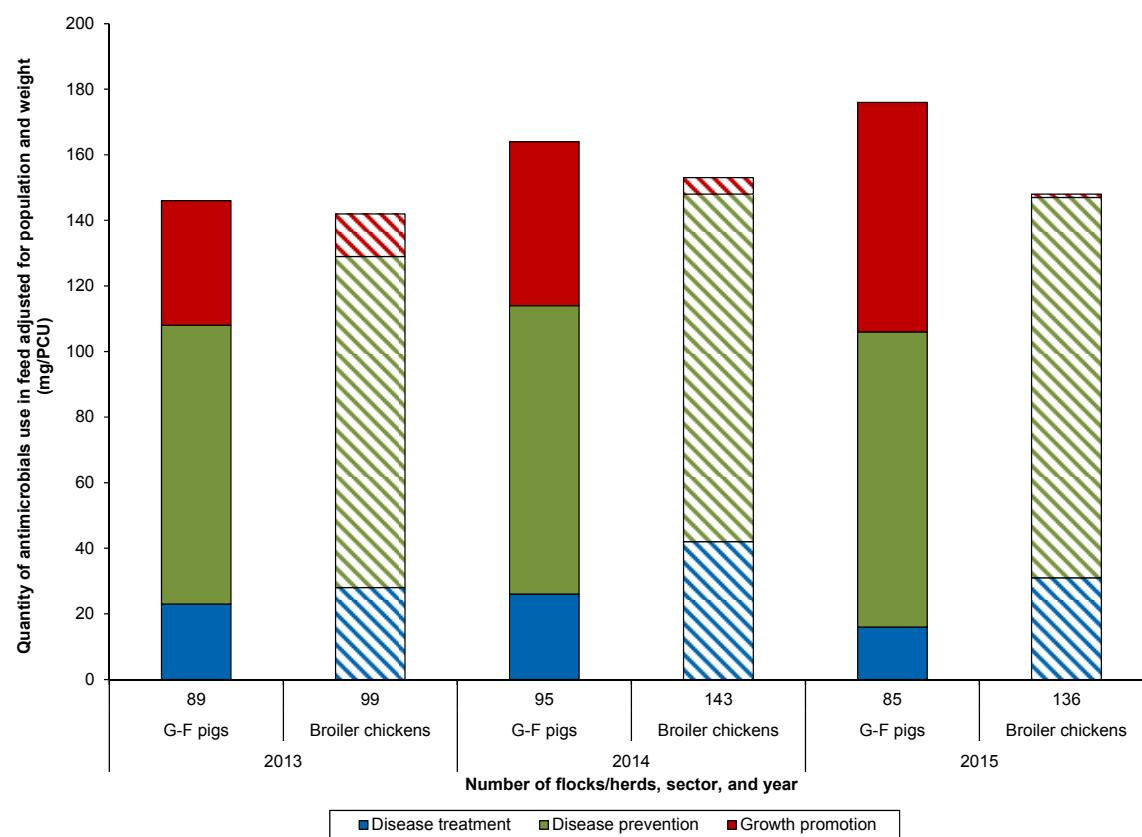
PCU = population correction unit; total number of pigs in the sampled grower-finisher herds x 65 kg/pig (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

Through the *Farm Surveillance*, we collected data on the primary reasons for use: growth promotion, disease prevention or therapy (disease treatment). For disease prevention and therapy, we collected more information about specific conditions (data shown in Chapter 3—Antimicrobial use in animals). In both broiler poultry and grower-finisher swine, the predominant reason for administering antimicrobials was for disease prevention (Figure 1. 10).

In 2015, the reported use for growth promotion purposes in broiler poultry declined. The reason for this decline in use was believed to be due to anticipatory changes by the industry ahead of expected regulatory changes⁴. In contrast, the reported growth promotion use increased in grower-finisher pigs in 2015. Note that reported total use also increased in grower-finisher pigs (Figure 1. 7).

Figure 1. 7 Overall antimicrobial quantity, adjusted for populations and weights by primary reason for use, 2015



Data source: CIPARS (Farm) 2015.

G-F = Grower-finisher pigs.

Swine data are for antimicrobial use in feed only; chicken data include all routes of administration.

Ionophores and chemical coccidiostats were excluded from this analysis.

⁴ Veterinary Drugs Directorate - Health Canada. Available at: <http://www.hc-sc.gc.ca/dhp-mps/vet/antimicrob/amr-notice-ram-avis-20140410-eng.php>. Accessed February, 2017.

CEFTRIAXONE RESISTANCE IN NON-TYPHOIDAL *SALMONELLA* AND GENERIC *ESCHERICHIA COLI*

Ceftriaxone is a Category I antimicrobial classified by Health Canada to be of very high importance to human medicine⁵. This antimicrobial is used to treat a variety of human infections. Although ceftriaxone is not used in animals, another 3rd generation cephalosporins (i.e., ceftiofur) is used to treat and prevent a variety of animal infections. Ceftriaxone and ceftiofur are very similar antimicrobials and, in most situations, if an isolate is resistant to one of these drugs it will also be resistant to the other. Beginning in 2015, CIPARS started using an antimicrobial susceptibility test panel that only contains ceftriaxone (the panel no longer includes ceftiofur); hence we are only reporting resistance to ceftriaxone. However, the antimicrobial use surveillance does capture data about ceftiofur use.

In 2015, CIPARS observed a reduction in reported use of ceftiofur on broiler chicken farms and changing resistance to ceftriaxone in *Salmonella* from humans, chickens, and chicken meat (Figure 1.11). In mid-2014 (Figure 1.8 and Figure 1.9), the poultry industry implemented a national ban on the use of Category I antimicrobials for disease prevention purposes. Consistent with the timing of this ban, reported ceftiofur use in broiler chickens has continued to decrease and dropped to 0% among participating flocks in 2015.

CIPARS data appear to be measuring the effects of the industry-led initiative to eliminate ceftiofur use for disease prevention as reflected by the resistance data in both *Salmonella* and *E. coli*. Resistance to ceftriaxone among *Salmonella* isolates from chickens, chicken meat and humans dropped in 2015 (Figure 1.8). While the magnitude of the changes in resistance observed in humans over time appears small, year over year, they are often significant as each data point represents thousands of isolates. Resistance among *E. coli* isolates from chickens and chicken meat also dropped in 2015 (Figure 1.9). Unfortunately, there currently are no data about generic *E. coli* from humans.

The effect of *Salmonella* serovar deserves brief mentioning (data not shown). Among the *Salmonella* isolates from humans, those that were resistant to ceftriaxone were mainly *S. Heidelberg*; in 2015, 68% (83/122) of isolates resistant to ceftriaxone were *S. Heidelberg*. Among resistant isolates from chicken(s) (farm, abattoir, and retail), ceftriaxone resistance was mostly commonly observed in isolates of *S. Kentucky* and *S. Heidelberg*; in 2015 53% (47/89) were *S. Kentucky* and 30% (27/89) were *S. Heidelberg*.

In summary, the industry-led initiative to eliminate ceftiofur use for disease prevention appears to have the desired effect and has resulted in reduced reported use in broiler chicken as well as reduced resistance in both *E. coli* and *Salmonella* from chickens and chicken meat based on CIPARS data.

⁵ Health Canada. 2009. Categorization of antimicrobial drugs based on importance in human medicine. Available at: www.hc-sc.gc.ca/dhp-mps/vet/antimicrop/amr_ram_hum-med-rev-eng.php. Accessed February 2015.

Figure 1. 8 Reduction in reported use of ceftiofur on farm and changing resistance to ceftriaxone in non-typhoidal *Salmonella* from humans and chicken sources, 2003–2015

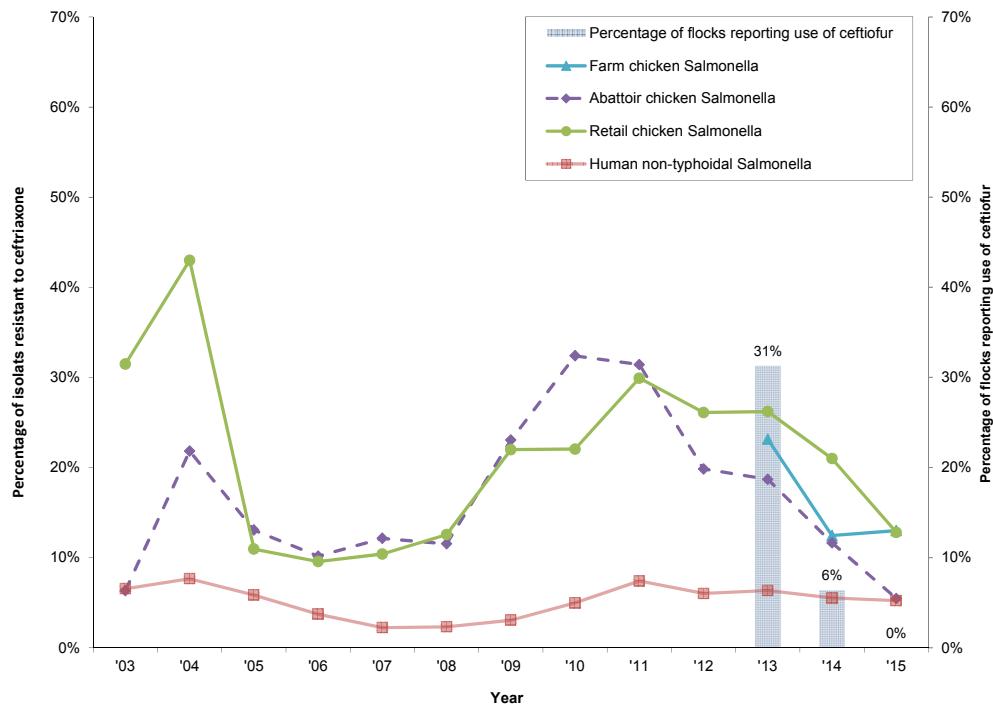
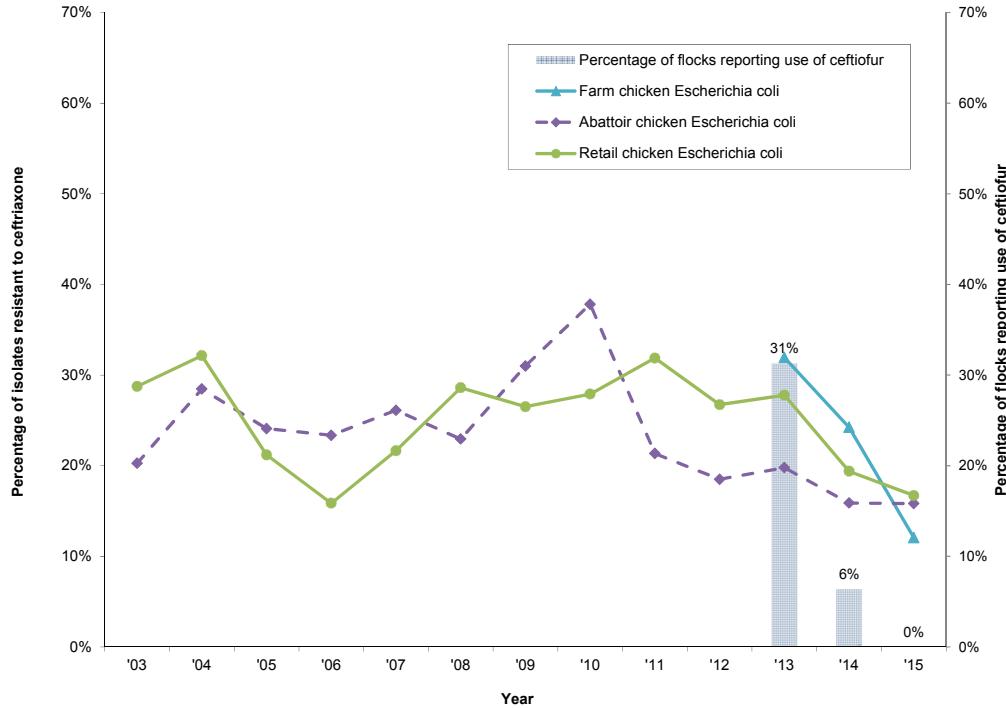


Figure 1. 9 Reduction in reported use of ceftiofur on farm and changing resistance to ceftriaxone in *Escherichia coli* from chicken sources, 2003–2015



Data source: CIPARS, 2015.

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FLUOROQUINOLONE RESISTANCE

FLUOROQUINOLONE RESISTANCE IN *CAMPYLOBACTER*

Fluoroquinolone resistance in *Campylobacter* is one of the main issues of concern to CIPARS. Ciprofloxacin (a fluoroquinolone) is an antimicrobial of very high importance to human medicine (Category I), which is commonly used in people to treat a variety of infections.

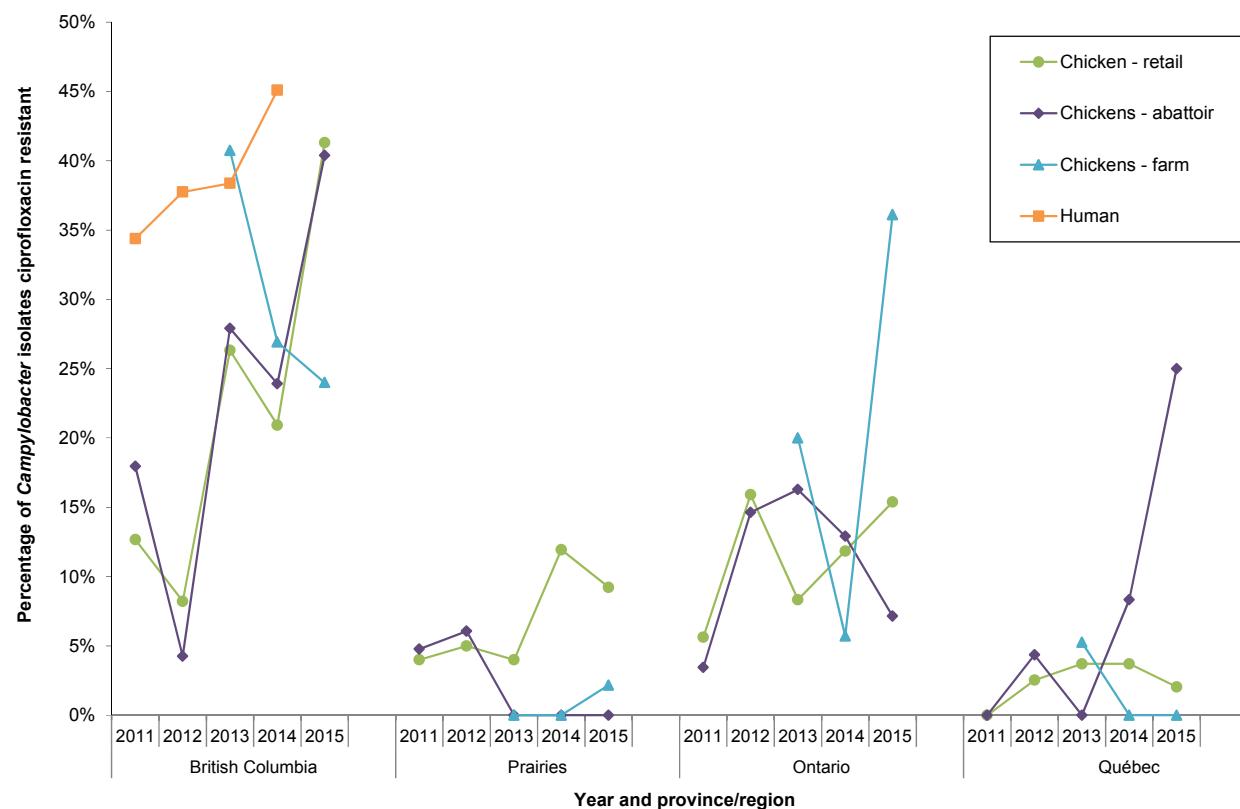
Resistance to ciprofloxacin in *Campylobacter* from chicken varies over time and across regions. Resistance to ciprofloxacin in *Campylobacter* increased in British Columbia at the abattoir and retail levels in 2015, as compared to 2014, but resistance decreased at the farm level (Figure 1. 10). Resistance at the farm level increased in Ontario and was higher in Ontario than in British Columbia in 2015. Although a large increase in resistance at abattoir was observed in Québec in 2015, it only reflected a few isolates (2/8 isolates were resistant to ciprofloxacin) and the increase was not statistically significant.

Despite the different and changing trends in resistance to ciprofloxacin among *Campylobacter* isolates from different surveillance components and regions, there has been no reported fluoroquinolone use in broiler chickens since 2013. CIPARS continues to work with producers and veterinarians to explore other potential antimicrobial uses and management factors that might explain the variable levels of resistance to ciprofloxacin observed across the regions.

A high proportion of human *Campylobacter* cases from British Columbia was also resistant to fluoroquinolones⁶. However, with these limited human data (British Columbia only), we are unable to determine to what extent fluoroquinolone-resistant *Campylobacter* from animals and food contribute to resistant infections in people.

⁶ Antimicrobial Resistance Trends in the Province of British Columbia – 2014 Report. BCCDC. Available at: http://www.bccdc.ca/resource-gallery/Documents/AMR%202014%20Report-3NOV2015_FINAL.pdf. Accessed March 2017.

Figure 1. 10 Trends of ciprofloxacin resistance in *Campylobacter* isolates from chicken(s), by province/region, 2011–2015



Data source: CIPARS 2011–2015; human data are from the Antimicrobial Resistance Trends in the Province of British Columbia—2014 Report. BC Center for Disease Control.

FLUOROQUINOLONE RESISTANCE IN *ESCHERICHIA COLI* AND *SALMONELLA*

Although the majority of resistance to fluoroquinolones has been observed in *Campylobacter* isolates, CIPARS has noted the emergence of fluoroquinolone resistance in *E. coli* and *Salmonella*. This is still a rare occurrence. One potential explanation for the rarity of fluoroquinolone resistance in non-*Campylobacter* bacteria is that there are multiple and different mutational sites (genes) involved in the expression of this resistance. However, the breadth of organisms in which we are observing fluoroquinolone resistance suggests that there may be a common use selection pressure.

Among CIPARS and FoodNet Canada agri-food isolates, 31 fluoroquinolone-resistant *E. coli* isolates were recovered from 2011–2015; 6 isolates were from 2015 and were from chicken(s) (1 farm and 2 retail—both from FoodNet Canada), ground beef (FoodNet Canada) and ground turkey (CIPARS retail). Since 2011, we have detected ciprofloxacin resistance in 24 *Salmonella* isolates from agri-food sources; 11 were from 2015 from chickens on-farm and clinical submissions from cattle (and 1 horse).

When CIPARS started in 2002, nearly all *S. Kentucky* isolates were fully susceptible to all antimicrobials tested. Beginning in 2004/05, we started seeing resistance to streptomycin and

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tetracycline. Then in later years (2009/10), resistance to β -lactam antimicrobials (amoxicillin-clavulanic acid, ceftiofur, cefoxitin, ampicillin and ceftriaxone) started to emerge, often in conjunction with resistance to streptomycin and tetracyclines (data not shown). More recently, isolates with this pattern have also shown resistance to nalidixic acid, which is a quinolone and can be an indicator of emerging resistance to fluoroquinolones. Since 2011, 42 *S. Kentucky* isolates from agri-food sources have shown resistance to nalidixic acid; 3 quarters of these ($n = 32$) were detected in 2015.

In addition to the large increase in resistance to nalidixic acid in 2015, resistance to ciprofloxacin was observed for the first time in agri-food *S. Kentucky* isolates and first time ever in any *Salmonella* serovar recovered from chicken(s). Another 32 *S. Kentucky* isolates from farm chickens were resistant to all β -lactam antimicrobials tested; 23 (72%) of these were also resistant to nalidixic acid. This resistance pattern was also seen in 2 *S. Kentucky* isolates recovered from retail chicken in 2015. All agri-food *S. Kentucky* isolates with this resistance pattern recovered in 2015 were from British Columbia except 1 CIPARS retail chicken isolate from Alberta. British Columbia is the same region where fluoroquinolone resistance first emerged in *Campylobacter* and is the only region where broiler chicken farms participating in CIPARS have reported the use of enrofloxacin (a fluoroquinolone; reported in 2013). There has been no reported enrofloxacin use in broiler chickens in British Columbia or any other region in Canada since 2013; however, it is possible that this drug is being used at the breeder level. Because the emerging resistant *S. Kentucky* isolates do not all show the same pattern of resistance (i.e., they are resistant to different combinations of antimicrobials tested), this emergence is suggestive of non-clonal spread.

Fluoroquinolone resistant non-typhoidal *Salmonella* isolates from humans were mainly serovars Kentucky, Enteritidis and Typhimurium. There were 117 of these isolates since 2011; 19 non-typhoidal human ciprofloxacin-resistant human isolates were from 2015.

Unexpectedly, in 2015, most of the resistant isolates from humans were serovar Kentucky ($n = 10$). Finding Kentucky isolates in humans is important and something to watch over time as this is a very common serovar in chicken but it historically has been rarely recovered from humans. In contrast to the resistance patterns observed in animal and food Kentucky isolates, only 5 of all *S. Kentucky* isolates from humans were resistant to the β -lactams and none of these were resistant to nalidixic acid. Of the *S. Kentucky* isolates from humans since 2011 ($n = 62$), 66% (41/62) were resistant to the fluoroquinolones and quinolones. Previous analysis of Canadian *S. Kentucky* isolates concluded that human infections were not acquired from domestically produced food⁷. The same study observed that of those patients with travel history ($n = 11$), all had travelled to Africa. This is similar to previous work in Europe that linked infection with ciprofloxacin resistant *S. Kentucky* to travel to countries in Africa⁸.

⁷ Mulvey, MR, Boyd DA, Finley R, Fakharuddin K, Langner S, Allen V, et al. Ciprofloxacin-Resistant *Salmonella enterica* serovar Kentucky in Canada. *Emerg Infect Dis.* 2013 June; 19(6): 999–1001.

⁸ Le Hello S, Hendriksen RS, Doublet B, Fisher L, Nielsen EM, Whichard JM, et al. International spread of an epidemic population of *Salmonella enterica* serovar Kentucky ST198 resistant to ciprofloxacin. *J Infect Dis.* 2011;204:675–84.

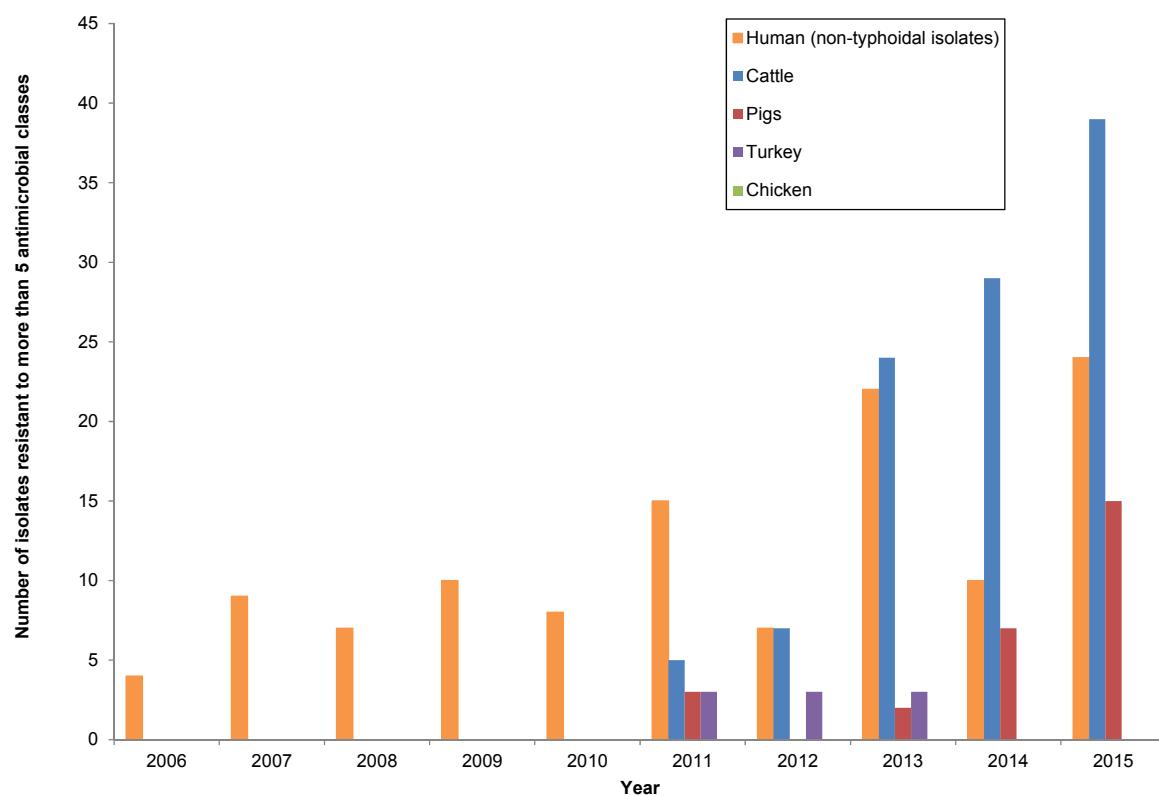
INCREASING NUMBER OF HIGHLY RESISTANT ISOLATES

CIPARS routinely tests for resistance to 6 or 7 antimicrobial classes (dependent on the antimicrobial susceptibility panel used each year); in 2015, 7 different drug classes were tested. The number of highly resistant (defined as those resistant to more than 5 antimicrobial classes) agri-food *Salmonella* isolates has increased over time (Figure 1. 11). Between 2006 and 2010, no agri-food *Salmonella* isolates were resistant to more than 5 classes. Since 2011, there has been a small but increasing number of highly resistant isolates. Most of the highly resistant isolates from agri-food sources have been recovered from clinically sick cattle; and most of these have been *S. Typhimurium* (59/104; 57%) and *S. Dublin* (38/104; 37%). While this trend is important to monitor, the results need to be interpreted with caution. CIPARS does not receive all clinical *Salmonella* isolates from agri-food sources; some provincial laboratories send all their *Salmonella* isolates to the National Microbiology Laboratory (NML) at Guelph, whereas others may only send a subset. Some submissions may also be clustered around disease outbreak events and thus may represent repeat submissions from the same animal or farm. In addition to cattle, there have been a small but growing (especially since 2014) number of highly resistant *Salmonella* isolates from pigs (mostly *S. Ohio* var 14+ [n = 10] and *S. Typhimurium* [n = 8]) and a small number from turkeys (all *S. Indiana*). No highly resistant *Salmonella* isolates have been detected from chicken sources.

The number of highly resistant *Salmonella* isolates from humans has also been growing. Five human isolates have shown resistance to all 7 antimicrobial classes tested: 1 *S. 4,[5],12:i:-* (2012), 2 *S. Newport* (2013, 2014), 1 *S. Dublin* (2013) and 1 *S. Kentucky* (2015). Just 1 agri-food isolate (*S. Typhimurium*) has shown resistance to all classes tested. This isolate was from a clinical cattle sample submitted in 2014.

The number of highly resistant agri-food *E. coli* isolates remains small and varies over time (data not shown). Two agri-food *E. coli* isolates have shown resistance to all 7 classes tested: 1 isolate from a pig sample collected on farm in 2011 and the other from a retail beef sample collected in 2013. Unlike the pattern for *Salmonella*, in most years, the greatest number of highly resistant *E. coli* isolates was recovered from chicken sources (38/69; 55%). Twenty-six percent (18/69) were from pigs, 10% (7/69) from turkeys and 9% (6/69) from cattle. Since 2010, the total number of highly resistant *E. coli* isolates was lowest in 2015 (n = 6).

Figure 1. 11 Number of highly resistant *Salmonella* isolates from human and agri-food sources, 2006–2015



Data source: CIPARS 2006–2015.

CHAPTER 2—ANIMAL HEALTH STATUS AND FARM INFORMATION



The data presented in this section pertains to pertinent farm-level animal health status and CIPARS sentinel farm information for both broiler chicken and grower-finisher pigs.

BROILER CHICKEN HEALTH AND FARM INFORMATION RELEVANT TO ANTIMICROBIAL USE AND ANTIMICROBIAL RESISTANCE

KEY FINDINGS

MORTALITY

The mortality rate decreased slightly between 2014 and 2015 from 3.5% to 3.4%.

CHICK SOURCES

Information on the chicks/hatching egg sources was also collected. This operational factor has been hypothesized as a risk factor for the presence of zoonotic enteric pathogens and antimicrobial-resistant bacteria harmful to people^{9,10}.

Of the total number of chicks placed in 2015, 89% were from the same province, 11% were imported, and less than 1% were sourced from other provinces (Figure 2. 1). Most barns sampled had chicks of domestic origin (95%, 129/136). The number of producers reporting imported chicks was highest in the Prairies (26%, 10/38) (Figure 2. 2). The proportion of

⁹ Agerso et al. 2014. Spread of extended spectrum cephalosporinase-producing *Escherichia coli* clones and plasmids from parent animals to broilers and to broiler meat in a production without use of cephalosporins. *Foodborne Pathogens and Disease* 11:740-746. Available at: <http://online.liebertpub.com/doi/pdf/10.1089/fpd.2014.1742>. Accessed October 2016.

¹⁰ Nilsson O. 2014. Vertical transmission of *Escherichia coli* carrying plasmid-mediated AmpC (pAmpC) through the broiler production pyramid. *Journal of Antimicrobial Chemotherapy*. 69:1497-1500. Available at: <http://jac.oxfordjournals.org/content/69/6/1497.full.pdf+html>. Accessed October 2016.

imported chicks placed in the barn ranged from 7% to 100%, depending on the province/region.

DIAGNOSIS OF DISEASES IN BROILER FLOCKS

The number of flocks diagnosed with common broiler diseases remained stable in the last 3 years (Figure 2.3 and Figure 2.4).

Diseases associated with avian pathogenic *E. coli* (APEC) were reported across all provinces/region. Yolksacculitis was diagnosed in 4 flocks in British Columbia, 5 flocks in the Prairies, 4 flocks in Ontario, and one flock in Québec (10%, 14/135 of flocks overall). Septicemia, also related to APEC (and other Gram-positive organisms such as *Staphylococcus* spp.), was also reported in 13% (18/135) of flocks across all provinces/regions and was highest in Ontario (22%, 11/49 flocks) (Figure 2.3). Unlike in Ontario and Québec, in British Columbia and the Prairies there was no antimicrobials administered via feed for treatment of APEC-associated diseases (yolksacculitis and septicemia); however, limited quantities of antimicrobials via water were used for treatment (British Columbia, 4 mg/PCU; Prairies, 8 mg/PCU). Another APEC-associated disease, airsacculitis, was detected in 4% (6/135) of broiler flocks. The diagnosis of APEC-associated localized and systemic diseases may partially explain the usage of antimicrobials for treatment purposes (e.g., trimethoprim and sulfonamides in feed and sulfonamides in the water). Also APEC-associated diseases might partially explain the preventive use of gentamicin and lincomycin-spectinomycin at the hatcheries. Currently, the use of alternative products to manage APEC (e.g., *E. coli* vaccine) is very limited; field efficacy data has yet to be evaluated.

Occasional diagnoses of necrotic enteritis, salmonellosis, vertebral osteomyelitis (*Enterococcus cecorum*), other bacterial or mixed bacterial infections and coccidiosis were reported (Figure 2.3). The relatively low frequency of flocks diagnosed with enteric diseases such as necrotic enteritis and coccidiosis could be explained, in part, by the routine preventive use of antimicrobials. As with APEC, there are limited non-antimicrobial alternatives to manage these enteric diseases.

The proportion of flocks diagnosed with any of the viral diseases (Figure 2.4) affecting broilers in Canada remained relatively low (0 to 3%). This is likely related to the widespread use of vaccines against these viral diseases at the hatchery and applications after chick placement. Regionally, the only viral disease that was diagnosed in greater than 10% of the flocks was Infectious Bursal Disease (IBD) in Québec (3 flocks).

To better understand the prevalence and incidence of avian pathogenic diseases beyond the farms sampled in CIPARS, we encourage readers to consult recent reports of diseases prevalent in the province/region and other animal health issues in the field¹¹.

¹¹ Ontario Animal Health Network. Available at: <http://oahn.ca/networks/poultry/>. Accessed July 2016.

BIOSECURITY

The median downtime period between 2 flock cycles was 17 days. Other biosecurity information¹² was collected and data are available upon request (e.g., disinfection, cleaning, water treatment, manure management).

ZOOTECHNICAL ADDITIVES AND VACCINES

The questionnaire also collected information on non-antimicrobial use alternatives to manage diseases. Such products are intended to prevent immunosuppression leading to infections that have complex etiology, thus potentially reducing the overall quantity of antimicrobials used.

Ninety-three percent (127/136) of flocks were vaccinated at the hatchery. Infectious Bronchitis Virus (IBV) vaccine (86%, 117/136) was most frequently applied, followed by Marek's disease (Herpesvirus of turkeys: 43% [59/136 flocks] and Marek's Disease-IBD vectored vaccine: 38% [51/136 flocks]).

After chick placement, 29% (39/136) of flocks were vaccinated. The most frequently used vaccines were IBV (Massachusetts strain: 13% [18/135 flocks] and Massachusetts-Connecticut strains: 4% [6/135 flocks]) and IBD (21%, 28/135 flocks).

An *Escherichia coli* vaccine¹³ was also reported (administered at the hatchery, 6% [8/136 flocks]; administered at the broiler farm, 2% [3/135 flocks]).

The coccidiosis vaccine, applied to 11% (15/136) of flocks at the hatchery, was administered to flocks that were raised under "raised without antibiotics (RWA)" (also known as antibiotic-free program [ABF] and are flocks that did not report any antibiotic, ionophore and chemical coccidiostat usage) or reduced antimicrobial program (i.e., as part of a rotational program to control coccidiosis, ABF-transitional flocks). In 2016, chemical coccidiostats could be used in poultry with RWA claims, but ionophores or antibiotics cannot be used¹⁴.

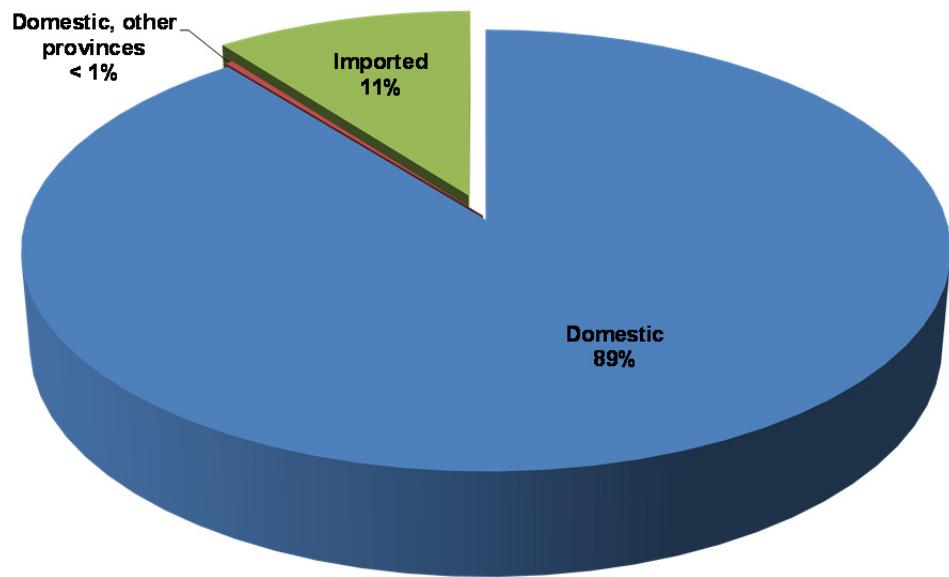
Zootechnical additives (probiotics, prebiotics, and essential oils) were used in 1 to 4% of the flocks sampled in 2015. Detailed vaccination information and zootechnical additives (temporal analysis) are available upon request.

¹² CFIA 2009. National On-Farm Avian Biosecurity Standard. Available at: http://www.inspection.gc.ca/DAM/DAM-animals-animaux/STAGING/text-texte/terr_biosec_avian_standard_1375192173847_eng.pdf. Accessed July 2016.

¹³ Labelled for the prevention of APEC infections. Available at: <https://bam.cvpservice.com/product/view/1198436>. Accessed December 2016. This is a live *aroA* gene deleted *Escherichia coli*, type O78.

¹⁴ Canadian Food Inspection Agency 2016. "Raised without the use of antibiotics" claims. Available at: <http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/method-of-production-claims/eng/1389379565794/1389380926083?chap=7#s6c7>. Accessed December 2016.

Figure 2. 1 Relative distribution of chick sources, 2015

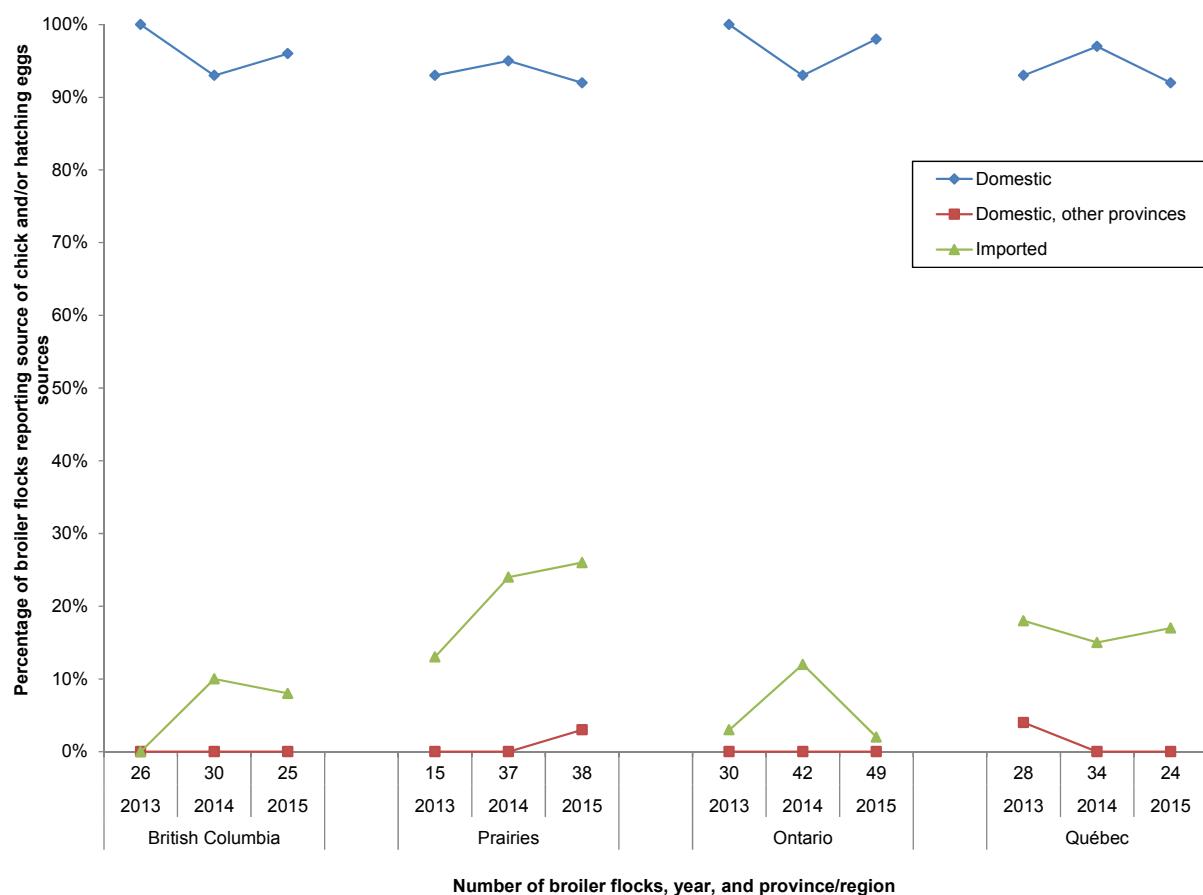


Domestic chicks = hatched within the province where the birds were raised.

Domestic, other provinces = hatched in a different province from where the birds were raised.

Imported = hatching eggs and/or chicks were sourced by the importing hatchery from the United States or other countries.

Figure 2. 2 Sources of chicks and/or hatching eggs placed in the barn sampled by province/region, 2013–2015



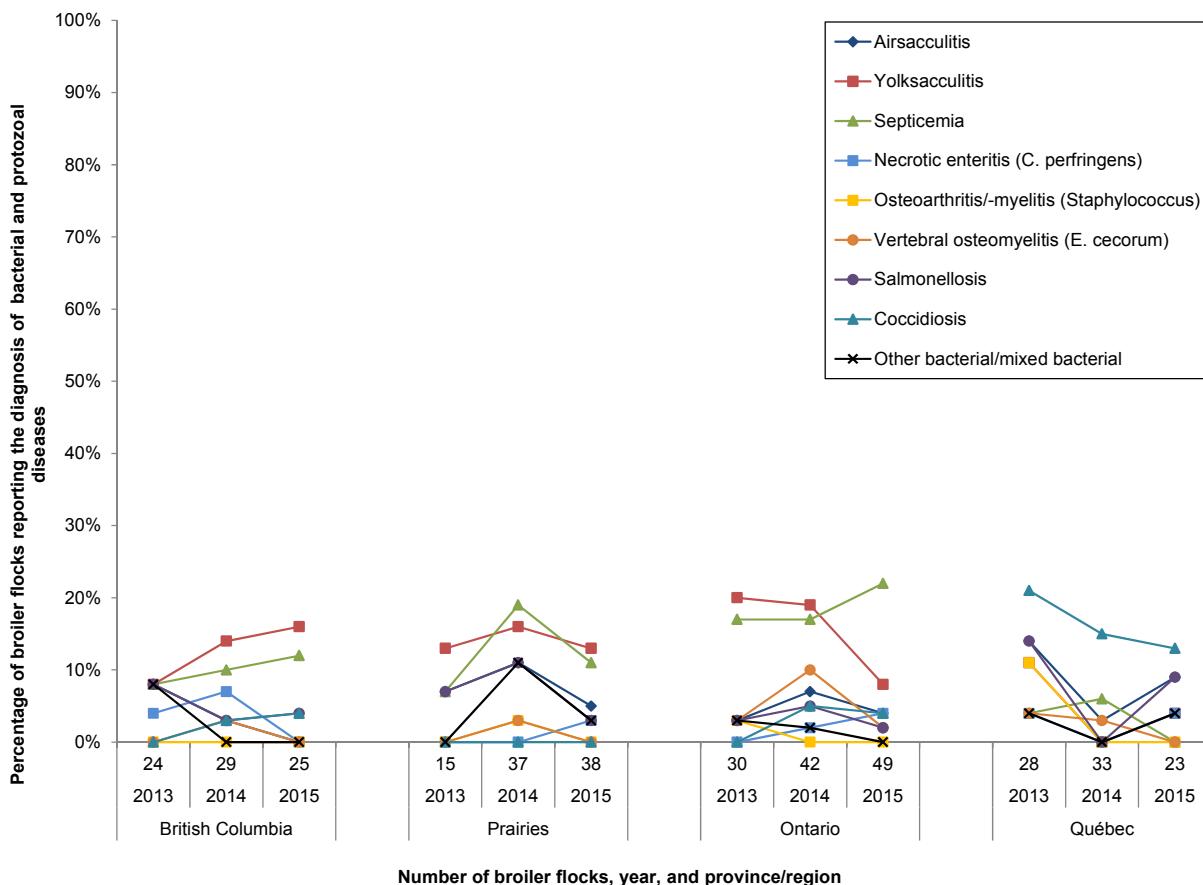
Domestic chicks = hatched within the province where the birds were raised.

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Imported = hatching eggs and/or chicks were sourced by the importing hatchery from the United States or other countries.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 2.3 Percentage of broiler flocks reporting bacterial and protozoal diseases by province/region, 2013–2015

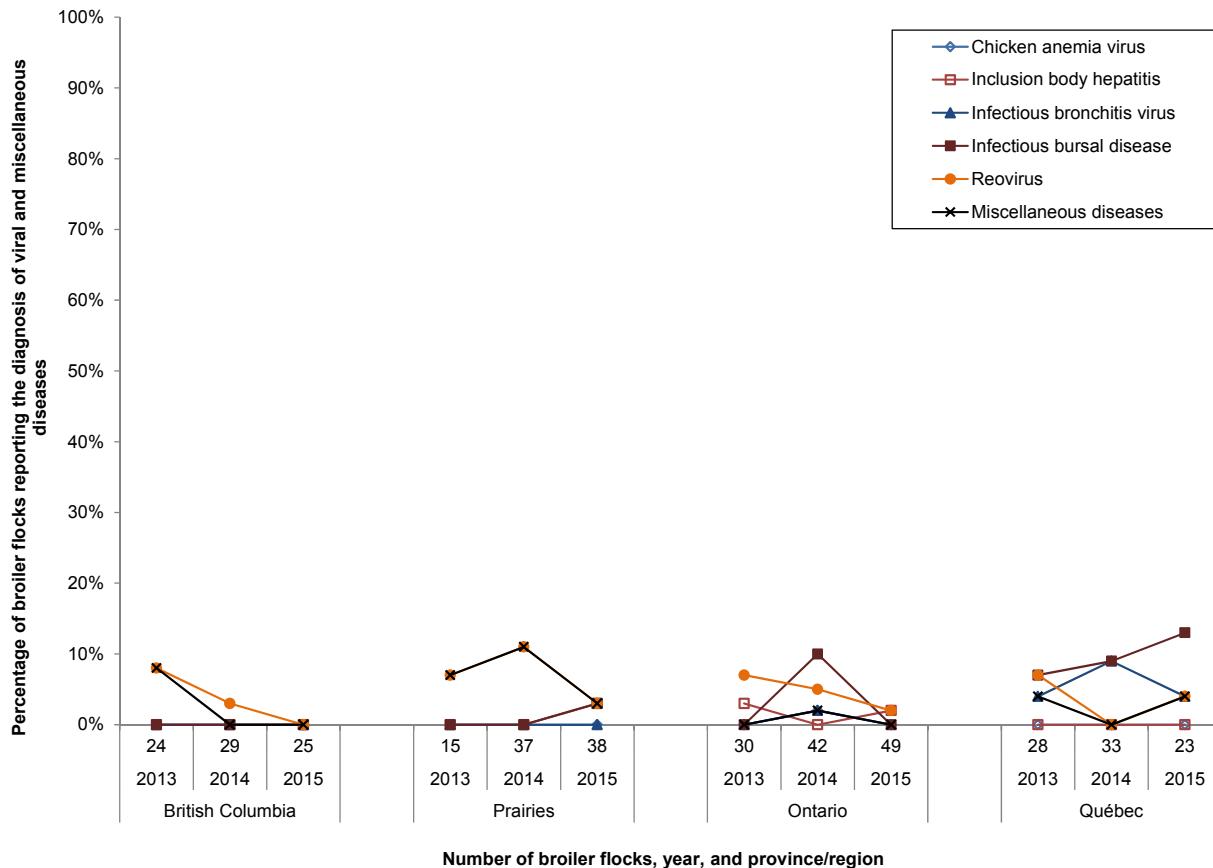


Province/region	British Columbia			Prairies			Ontario			Québec		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	24	29	25	15	37	38	30	42	49	28	33	23
Bacterial and protozoal disease												
Airsacculitis	8%	3%	0%	7%	11%	5%	3%	7%	4%	14%	3%	9%
Yolksacculitis	8%	14%	16%	13%	16%	13%	20%	19%	8%	11%	0%	4%
Septicemia	8%	10%	12%	7%	19%	11%	0%	2%	4%	4%	0%	4%
Necrotic enteritis (C. perfringens)	4%	7%	0%	0%	0%	3%	0%	2%	4%	11%	0%	0%
Osteoarthritis-/myelitis (Staphylococcus)	0%	0%	0%	0%	3%	0%	0%	0%	0%	4%	3%	0%
Vertebral osteomyelitis (E. cecorum)	0%	3%	0%	0%	3%	0%	3%	10%	2%	14%	0%	9%
Salmonellosis	8%	3%	4%	7%	11%	3%	3%	5%	2%	21%	15%	13%
Coccidiosis	0%	3%	4%	0%	0%	0%	0%	5%	4%	4%	0%	4%
Other bacterial/mixed bacterial	8%	0%	0%	0%	11%	3%	0%	2%	0%	4%	0%	4%

The respondents were instructed to select all applicable diseases and only one of "Confirmed positive", "Likely positive", "Likely negative", and "Confirmed negative". The respondents were also instructed to select all applicable tools to establish the health status of the broiler flocks. Only responses that were either "Confirmed positive" or "Likely positive" plus a response to either post-mortem or laboratory testing (or both methods) to confirm the diagnosis were included in the final data above.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 2. 4 Percentage of broiler flocks reporting the diagnosis of viral and miscellaneous diseases by province/region, 2013–2015



The respondents were instructed to select all applicable diseases and only one of "Confirmed positive", "Likely positive", "Likely negative", and "Confirmed negative". The respondents were also instructed to select all applicable tools to establish the health status of the broiler flocks. Only responses that were either "Confirmed positive" or "Likely positive" plus a response to either post-mortem or laboratory testing (or both methods) to confirm the diagnosis were included in the final data above.

In 2015, miscellaneous diseases include cellulitis and non-specific *E. coli* infections and chronic diarrhea due to vomitoxin.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

GROWER-FINISHER PIG HEALTH STATUS AND FARM INFORMATION RELEVANT TO ANTIMICROBIAL USE AND ANTIMICROBIAL RESISTANCE

KEY FINDINGS

DIAGNOSIS OF DISEASES IN GROWER-FINISHER PIG HERDS¹⁵

In 2015, Québec had a significantly higher proportion of grower-finisher pig herds with 7 or more diseases reported (48%) than the Prairies (21%) (Figure 2.5). Ontario grower-finisher pig herds had a significantly higher reported prevalence of *Mycoplasma*, Porcine Coronavirus Associated Disease (PCVAD), and Swine Influenza than grower-finisher pig herds in the Prairies in 2015. Also in 2015, Québec grower-finisher pig herds had a significantly higher reported prevalence of *Mycoplasma* than grower-finisher pig herds in the Prairies (Figure 2.7).

Antimicrobials were most commonly reported in grower-finisher pig herds in all 3 regions (Prairies, Ontario, and Québec) for the control or treatment of *Streptococcus suis* (29%, 24%, 38%) and *Lawsonia* (26%, 44%, 14%) in 2015 (Figure 2.7). Additionally, there was significantly more antimicrobial use reported for *Mycoplasma* in Ontario and Québec grower-finisher pig herds than in grower-finisher pig herds in the Prairies (Figure 2.7).

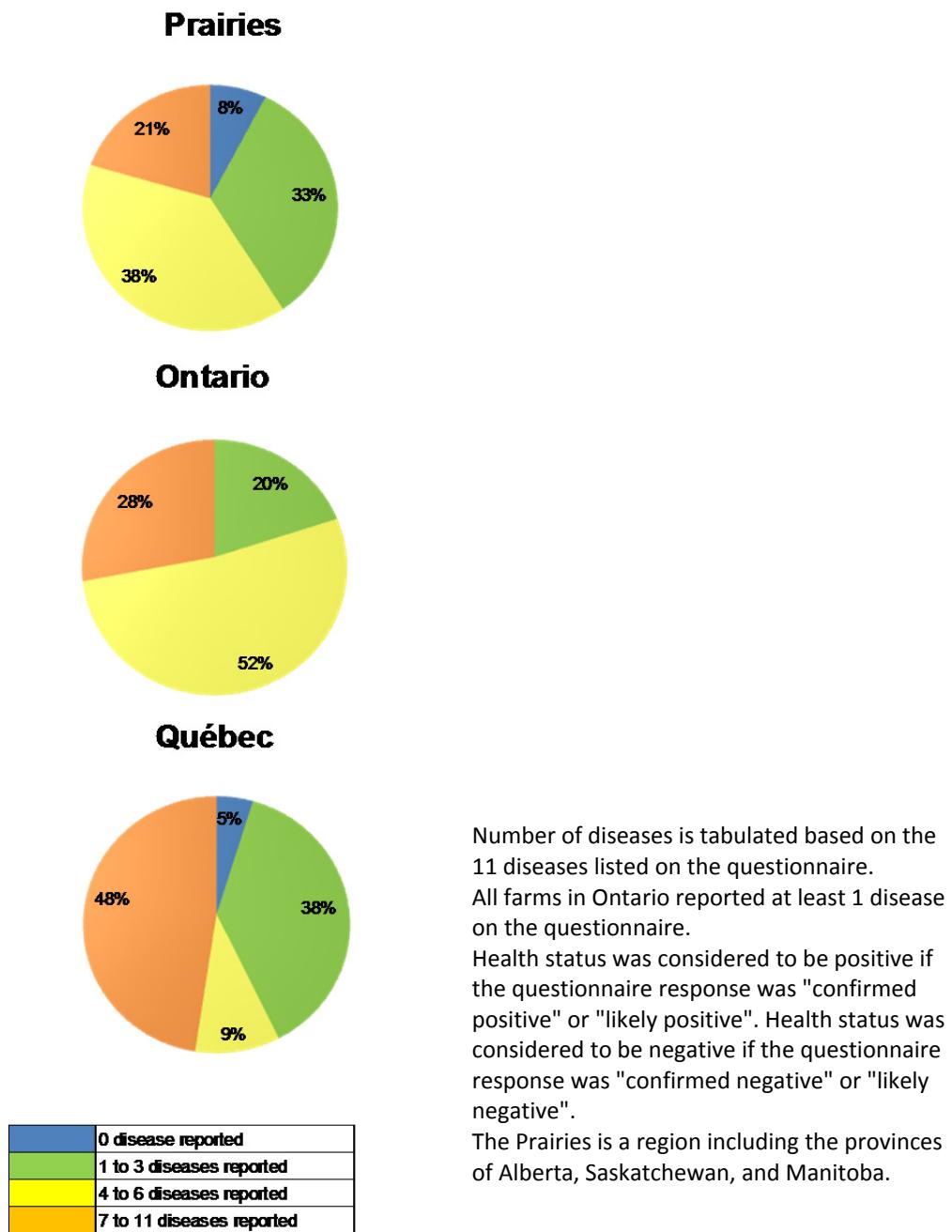
In 2015, there was significantly more reported antimicrobial use for *E. coli*, *Lawsonia*, *Mycoplasma*, and PCVAD in Ontario nurseries supplying CIPARS grower-finisher pig herds than in nurseries supplying CIPARS grower-finisher pig herds in the Prairies. Also in 2015, there was significantly more reported antimicrobial use for *E. coli*, *Mycoplasma*, and *Salmonella* in Québec nurseries supplying CIPARS grower-finisher pig herds than in nurseries supplying CIPARS grower-finisher pig herds in the Prairies (Figure 2.8).

In 2015, there was significantly more reported antimicrobial use for Erysipelas and Swine Influenza in Ontario sow herds supplying CIPARS grower-finisher pig herds than in sow herds supplying grower-finisher pig herds in the Prairies. There was also significantly more reported use for *E. coli* in Québec sow herds supplying CIPARS grower-finisher pig herds than in sow herds supplying grower-finisher pig herds in the Prairies (Figure 2.9).

¹⁵ For all statistical analyses, a *P*-value less than or equal to the level of significance of 0.05 (*P* ≤ 0.05) was used to indicate a significant difference between years. All statistically significant results are marked by the use of the words "significant" or "significantly" in the text.

Grower-finisher pig herds in Ontario and Québec were significantly smaller than in the Prairies in 2015 (Figure 2. 10). As well, the number of pig farms within 2 km of CIPARS grower-finisher pig herds was significantly higher in Ontario and Québec than in the Prairies (Figure 2. 10).

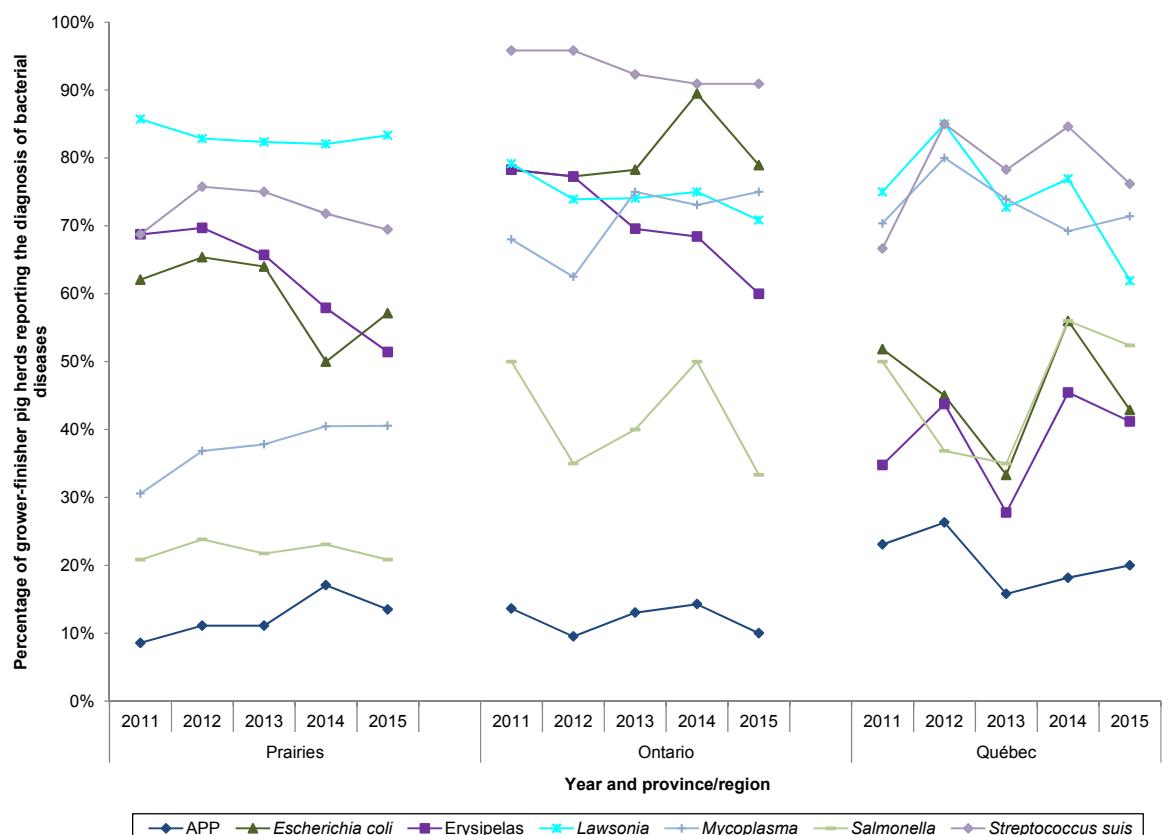
Figure 2.5 Number of infectious diseases reported by grower-finisher pig herds (n = 85) by provinces/region, 2015



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Figure 2. 6 Reported health status for diseases of grower-finisher pig herds by province/region, 2011–2015

a) Bacterial diseases



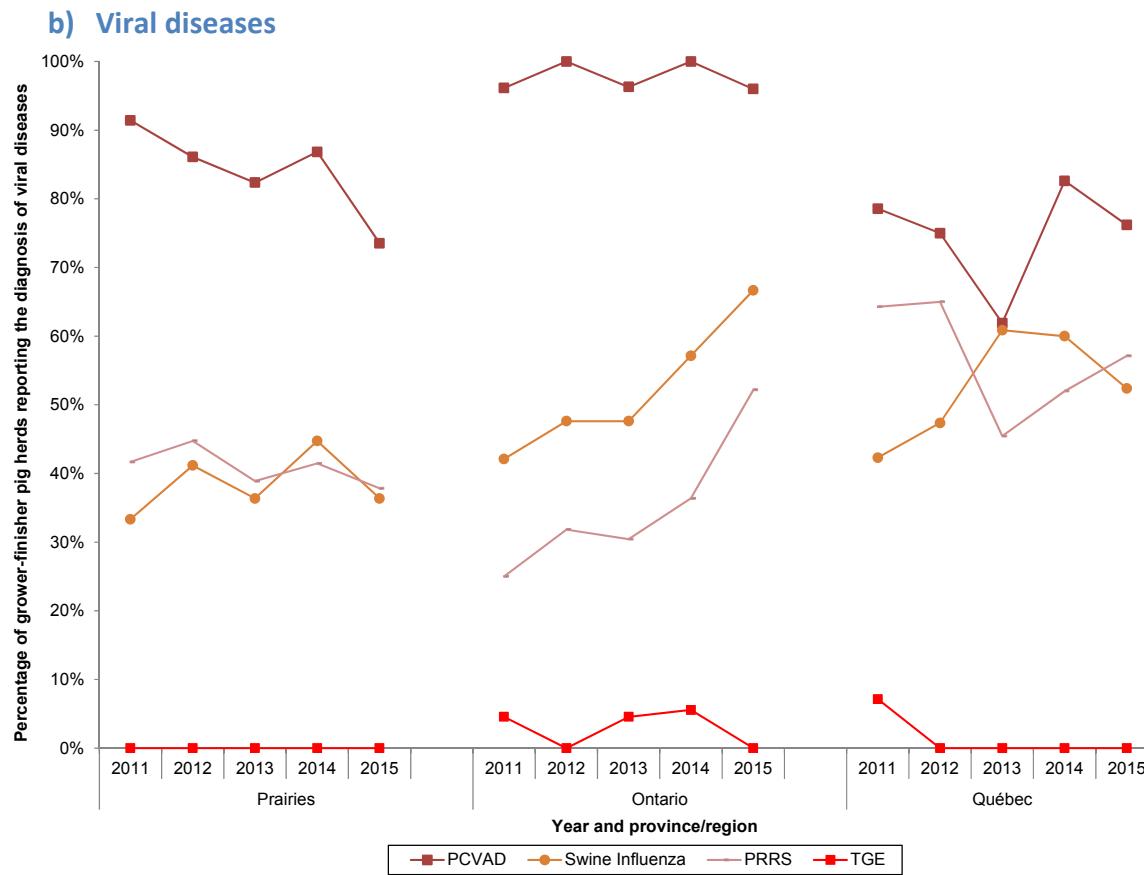
Province/region Year	Prairies					Ontario					Québec				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Bacterial disease/bacteria															
APP	9%	11%	11%	17%	14%	14%	10%	13%	14%	10%	23%	26%	16%	18%	20%
Escherichia coli	62%	65%	64%	50%	57%	78%	77%	78%	89%	79%	52%	45%	33%	56%	43%
Erysipelas	69%	70%	66%	58%	51%	78%	77%	70%	68%	60%	35%	44%	28%	45%	41%
Lawsonia	86%	83%	82%	82%	83%	79%	74%	74%	75%	71%	75%	85%	73%	77%	62%
Mycoplasma	31%	37%	38%	40%	41%	68%	63%	75%	73%	75%	70%	80%	74%	69%	71%
Salmonella	21%	24%	22%	23%	21%	50%	35%	40%	50%	33%	50%	37%	35%	56%	52%
Streptococcus suis	69%	76%	75%	72%	69%	96%	96%	92%	91%	91%	67%	85%	78%	85%	76%

APP = *Actinobacillus pleuropneumoniae*.

Health status was considered to be positive if the questionnaire response was "confirmed positive" or "likely positive". Health status was considered to be negative if the questionnaire response was "confirmed negative" or "likely negative".

Health status of nurseries and sow herds supplying CIPARS grower-finisher pig herds is available upon request. The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 2. 6 Reported health status for diseases of grower-finisher pig herds by province/region, 2011–2015 (cont'd)



PCVAD = Porcine Coronavirus Associated Disease.

PRRS = Porcine Reproductive and Respiratory Syndrome.

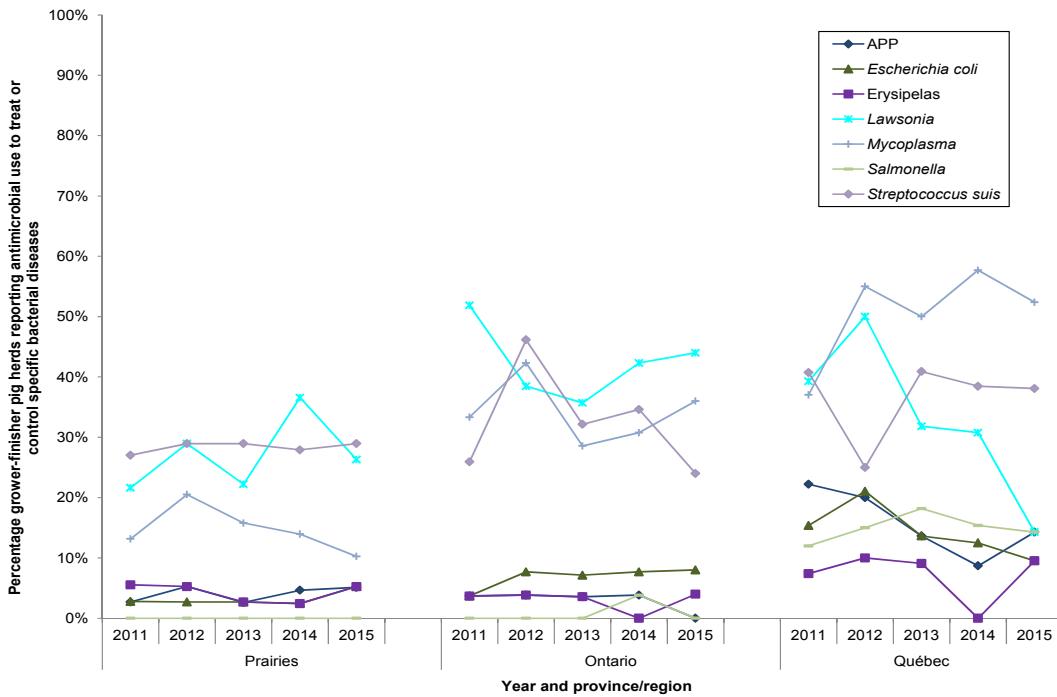
TGE = Transmissible gastroenteritis

Health status was considered to be positive if the questionnaire response was "confirmed positive" or "likely positive". Health status was considered to be negative if the questionnaire response was "confirmed negative" or "likely negative".

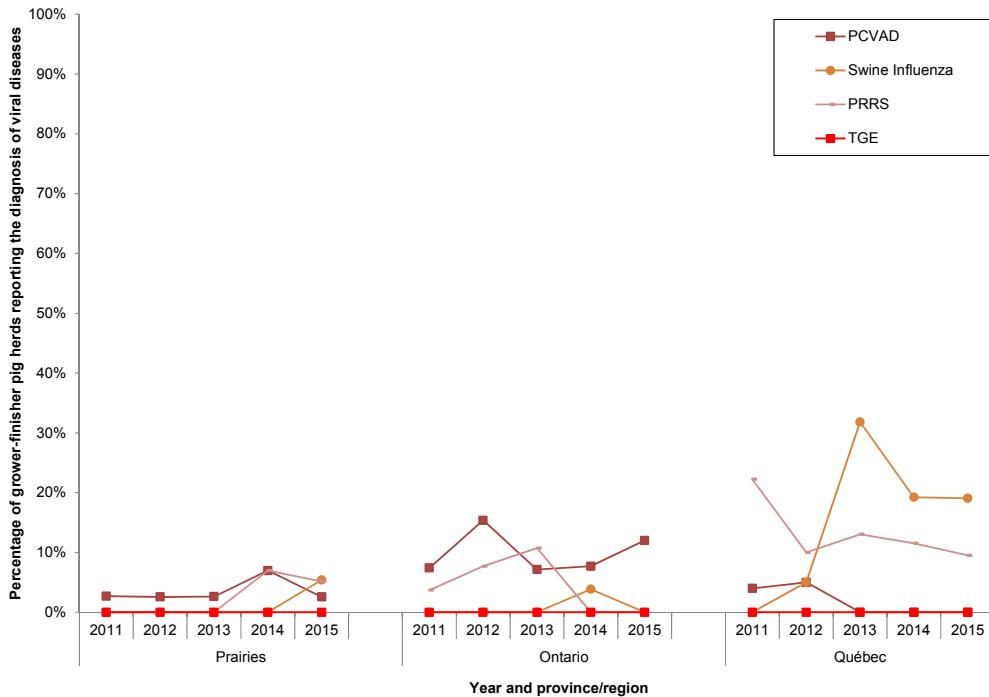
Health status of nurseries and sow herds supplying CIPARS grower-finisher pig herds is available upon request.
The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 2. 7 Reported antimicrobial use for specific diseases in grower-finisher pig herds by province/region, 2011–2015

a) Bacterial diseases



b) Viral diseases



See corresponding footnotes on the next page.

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APP = *Actinobacillus pleuropneumoniae*. PCVAD = Porcine Circovirus Associated Disease.

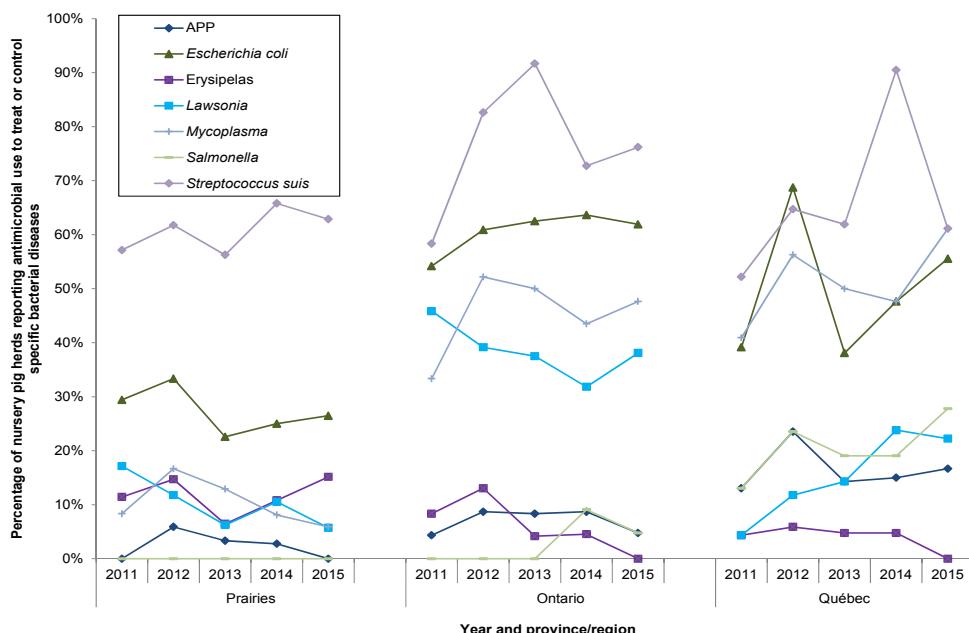
PRRS = Porcine Reproductive and Respiratory Syndrome. TGE = Transmissible gastroenteritis.

Health status was considered to be positive if the questionnaire response was "confirmed positive" or "likely positive". Health status was considered to be negative if the questionnaire response was "confirmed negative" or "likely negative".

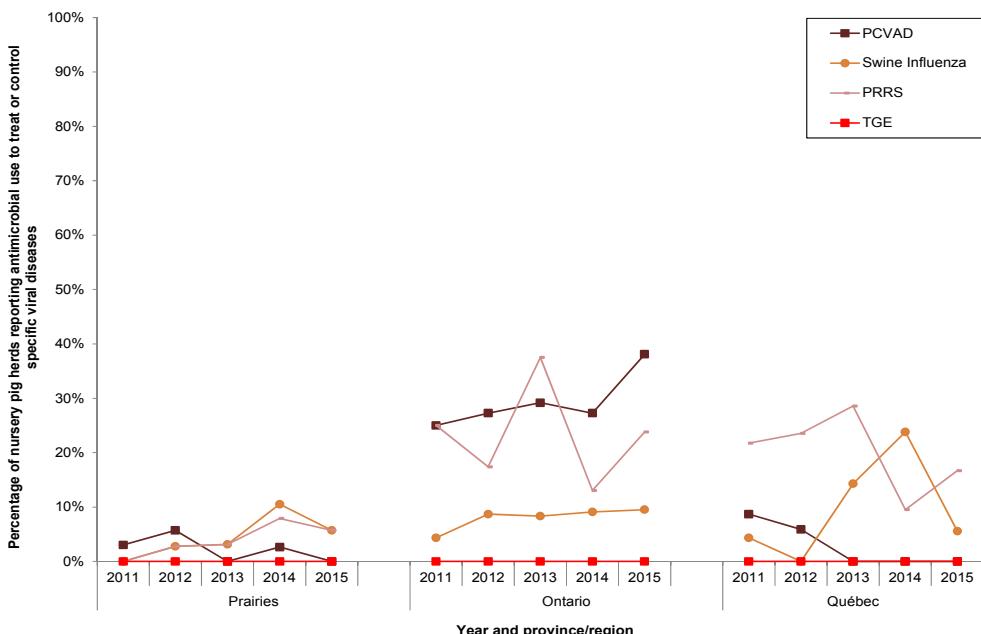
The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 2.8 Reported antimicrobial use for specific diseases in nurseries supplying grower-finisher herds by province/region, 2011–2015

a) Bacterial diseases



b) Viral diseases



See corresponding footnotes on the next page.

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

APP = *Actinobacillus pleuropneumoniae*.

PCVAD = Porcine Circovirus Associated Disease.

PRRS = Porcine Reproductive and Respiratory Syndrome.

TGE = Transmissible gastroenteritis.

Not all questionnaires were completed for all diseases listed.

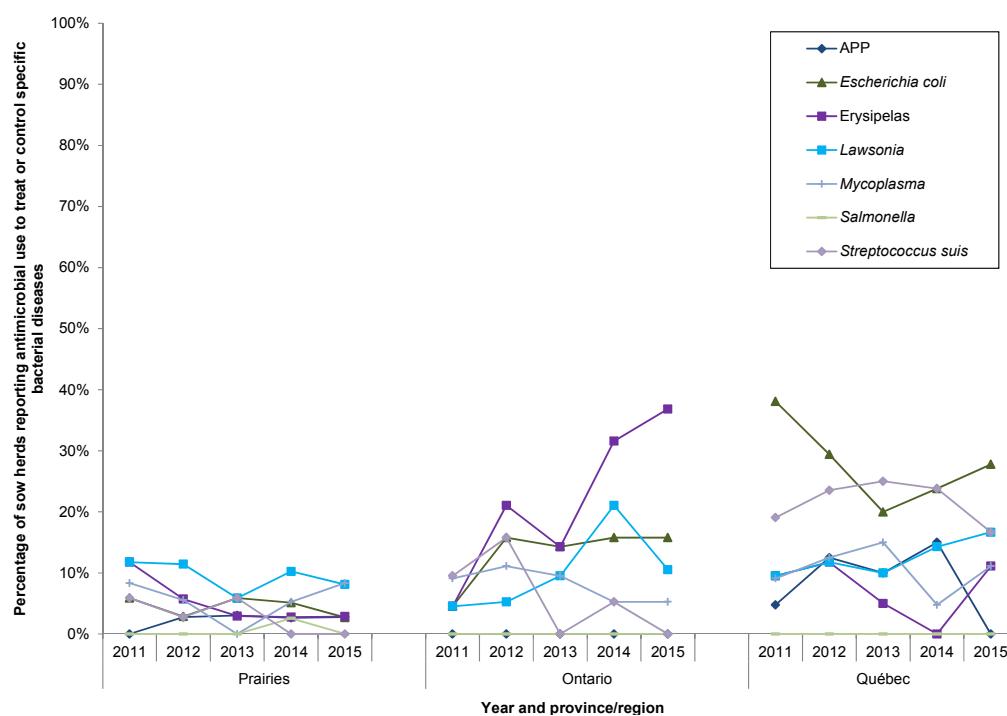
Health status was considered to be positive if the questionnaire response was "confirmed positive" or "likely positive". Health status was considered to be negative if the questionnaire response was "confirmed negative" or "likely negative".

There are 3 primary stages of pig production: suckling pigs (pre-weaning, in sow herds), nursery pigs (weaning to 25 kg), and grower-finisher pigs (25 kg to market weight). Data on antimicrobial use in suckling and nursery pigs is required to understand total antimicrobial exposure.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

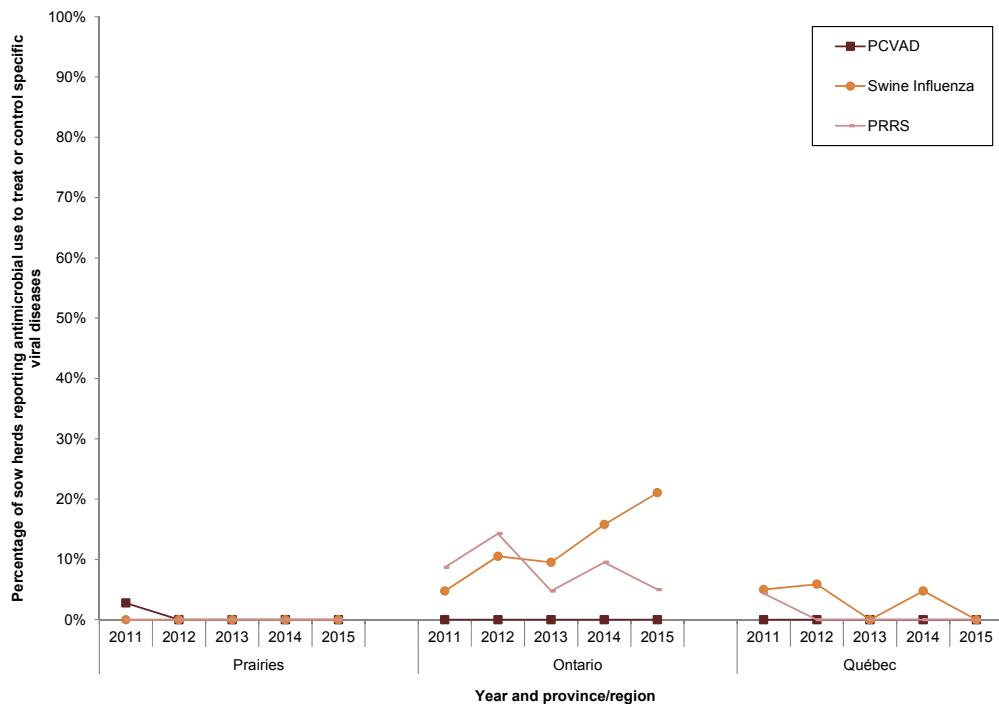
Figure 2. 9 Reported antimicrobial use for specific diseases in sow herds supplying grower-finisher pig herds by province/region, 2011–2015

a. Bacterial diseases



See corresponding footnotes on the next page.

b. Viral diseases



APP = *Actinobacillus pleuropneumoniae*.

PCVAD = Porcine Circovirus Associated Disease.

PRRS = Porcine Reproductive and Respiratory Syndrome.

Transmissible Gastroenteritis (TGE) was not included in the sow herd survey.

Not all questionnaires were completed for all diseases listed.

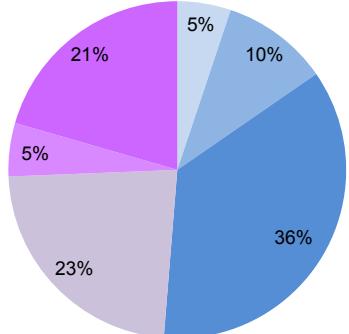
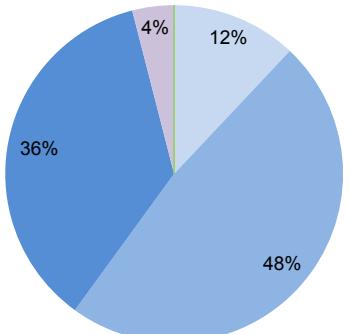
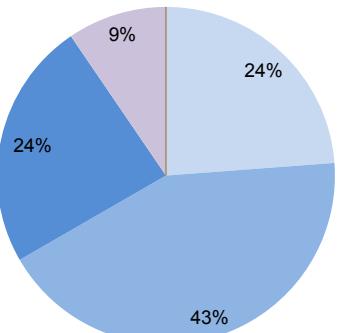
Health status was considered to be positive if the questionnaire response was "confirmed positive" or "likely positive". Health status was considered to be negative if the questionnaire response was "confirmed negative" or "likely negative".

There are 3 primary stages of pig production: suckling pigs (pre-weaning, in sow herds), nursery pigs (weaning to 25 kg), and grower-finisher pigs (25 kg to market weight). Data on antimicrobial use in suckling and nursery pigs is required in order to understand total antimicrobial exposure.

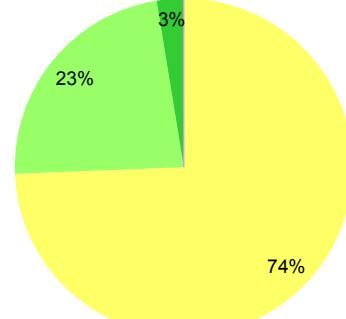
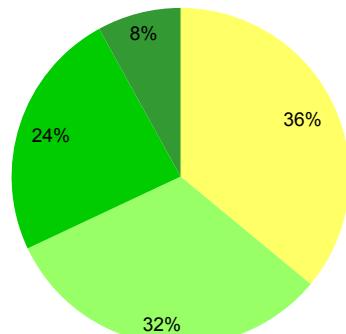
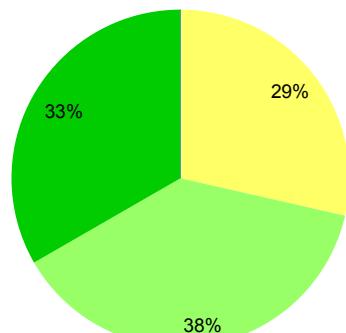
The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 2. 10 Demographics of grower-finisher pig herds by province/region (n = 85), 2015

a. Barn capacity

Prairies**Ontario****Québec**

b. Number of swine farms within 2 km

Prairies**Ontario****Québec**

< 1000 pigs
1000 to 1999 pigs
2000 to 2999 pigs
3000 to 3999 pigs
4000 to 4999 pigs
> 5000 pigs

0 swine farms
1 to 3 swine farms
4 to 6 swine farms
7 to 10 swine farms
> 10 swine farms

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

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CHAPTER 3—ANTIMICROBIAL USE IN ANIMALS



HOW TO READ THIS CHAPTER

This chapter highlights the most notable antimicrobial use (AMU) findings across the animal surveillance components of CIPARS for 2015: quantities of antimicrobials distributed for sale for use in animals, AMU in broiler chickens (on-farm), and AMU in grower-finisher pigs (on-farm).

The antimicrobial use data collected on farm (broiler chicken and grower-finisher pigs) is largely presented by antimicrobial except in the feed sections where some figures and tables are presented by antimicrobial class. The *Farm Surveillance* data are reported as both qualitative antimicrobial use metrics (e.g., number of farms reporting using an antimicrobial), as well as quantitative antimicrobial (active ingredient) use metrics (e.g., milligrams/population correction unit [mg/PCU] and the Canadian Defined Daily Dose for animals [DDDvetCA]/1,000 animal-days). These metrics were presented by class or antimicrobial.

Summary antimicrobial use data in feed are presented in Table 3. 6 and Table 3. 7 for broiler chickens and in Table 3. 9 and Table 3. 10 for grower-finisher pigs. These tables provide key antimicrobial use data including the number and percent of flocks/herds exposed to each listed antimicrobial (active ingredient), the number and percent of rations that contained each antimicrobial, the median number of days the herd/flock was fed the antimicrobial (days exposed), the percent of the flock/herds that was exposed to the antimicrobial, the median concentration of the antimicrobial in the feed (g/tonne), and various metrics described in the summary table below. The broiler section also summarizes the frequency and quantity of antimicrobials used via water or injection. The quantitative measure, mg/PCU, provides a standardized estimate of use that can be compared with estimates from other countries and surveillance programs. Beginning in 2015, CIPARS is reporting the quantity of antimicrobials (mg) adjusted by the Canadian average labelled daily dose to determine the number of daily doses animals under study received. Reporting AMU with this metric more precisely detects differences in antimicrobial use over time, between regions and animal species, than quantity of antimicrobials (kg) alone. Briefly the following antimicrobial use metrics (or indicators) were derived using specific numerators and denominators as described in Chapter 5—Design and Methods.

Table 3.0 Summary of antimicrobial use metrics measurements used in this chapter

Metric	Numerator	Denominator
Frequency of use, flock or herd	Number of flocks/herd exposed	Total flocks/herds sampled
Frequency of rations, flock or herd	Number of medicated or unmedicated rations	Total number of rations
kg (distribution data)	Antimicrobials (kg) distributed by CAHI member companies for use in production and companion animal in Canada	N/A
mg/population correction unit (mg/PCU)	Total quantity of antimicrobials consumed by the animals in mg	Population correction unit Biomass: total population minus half of the mortality rate, adjusted for standard weight of broiler (1 kg) or pig (65 kg)
mg/population correction unit (mg/PCU) (distribution data)	Total quantity of antimicrobials distributed for sale by CAHI member companies (mg)	Total quantity of antimicrobials distributed for sale by CAHI member companies (mg) Biomass: total population, adjusted for standard animal weights (kg) at treatment (see Chapter 5—Design and Methods)
nDDDvetCA/1,000 animal-days	Total quantity of antimicrobials consumed by the flock/herd in mg adjusted for Canadian average labelled daily dose (mg/DDDvetCA)	Total number of animals minus half of the mortality rate multiplied by the days each animal is in the study divided by 1,000

CAHI = Canadian Animal Health Institute.

N/A = not applicable.

NATIONAL OR PROVINCIAL/REGIONAL PREVALENCE ESTIMATES

Data for the Canadian Animal Health Institute CAHI and farm antimicrobial use components in this chapter are presented at the national and regional/provincial level.

- For broiler chickens, the 4 provinces/regions were British Columbia, Prairies (Alberta and Saskatchewan), Ontario, and Québec.
 - In broiler chickens, data combining all routes of administration at the national level (all contributing regions/provinces) are presented in the beginning of the section. Data are further stratified by province/region in the subsequent feed, water, and injection sections.
- For grower-finisher pigs, the 5 provinces (or 3 provinces/regions) were the Prairies (Alberta, Saskatchewan, and Manitoba), Ontario, and Québec.

TEMPORAL FIGURES AND DATA TABLES FOR SIGNIFICANCE TESTING

The CAHI data represent census type data; hence differences over time should represent true differences. Statistical significance testing is not appropriate for census type data.

All temporal figures and accompanying data tables presented in this chapter for the *Farm Surveillance* components depict the variation in antimicrobial use since the year surveillance was implemented or a significant change was made in the data collection; this is 2009 for grower-finisher pigs and 2013 for broiler chickens. For consistency across the farm components, statistical analyses were limited to comparison of 2015 results with: 1) 2014 results and 2) the first year of surveillance. Where temporal analyses are presented provincially/regionally for the *Farm Surveillance* components, the data are truncated to a maximum of 5 surveillance years. Therefore, temporal figures for grower-finisher pigs and broiler chickens are limited from 2011 to 2015 and 2013 to 2015 data, respectively.

To facilitate the assessment of significant results at a glance, all significant differences found have been highlighted in blue (or red for significant regional differences and purple to indicate significant differences in both year and region) in data tables underneath the temporal figures. Finally, for all statistical analyses, a *P*-value less than or equal to the level of significance of 0.05 (≤ 0.05) was used to indicate a significant difference between years. All statistically significant results are marked by the use of the words "significant" or "significantly" in the text. All other findings presented without this word should be considered as non-statistically significant and should be interpreted with caution.

BACKGROUND INFORMATION

QUANTITIES OF ANTIMICROBIALS DISTRIBUTED FOR SALE FOR USE IN ANIMALS

The CAHI, is the trade association representing the companies that develop, manufacture and distribute drugs for administration to animals in Canada. The association estimates that its members' sales represent about 90% of all sales of licensed animal health products¹⁶. Data on active antimicrobial ingredients distributed for sale by CAHI member companies were aggregated and voluntarily provided to CIPARS.

The CAHI data include all animal species, including those not covered by CIPARS farm-level surveillance. Distribution data should always be considered with other sources of information (such as farm-level surveillance and antimicrobial resistance findings) for any decision-making.

WHAT THE CANADIAN ANIMAL HEALTH INSTITUTE DATA DO NOT INCLUDE

The CAHI data do not include antimicrobials imported under the personal-use provision of the federal Food and Drugs Act Regulations (own use import—OUI), nor do they include imported active pharmaceutical ingredients (API), which are drugs in non-dosage form subsequently

¹⁶ Canadian Animal Health Institute – ABOUT US. Available at: <http://cahi-icsa.ca/about/>. Accessed July 2016.

compounded by a licensed pharmacist or veterinarian. Health Canada's Veterinary Drugs Directorate has proposed regulations regarding these importation processes¹⁷. These regulations include the requirement for Health Canada to collect information on quantities of antimicrobials sold by manufacturers, importers and persons who compound antimicrobials. These data would be stratified by animal species.

CAHI excludes from their data antimicrobials manufactured for export; hence the CAHI data reflect antimicrobials distributed by companies for use in animal in Canada.

The CAHI data do not include prescriptions filled at community pharmacies for antimicrobials to be used in companion or production animals (products labelled for use in humans).

POINTS OF NOTE REGARDING EVALUATION OF TRENDS

At the time of writing, some of the CAHI member companies re-stated their 2014 data. Hence the data included in this report differ slightly from the data presented in the CIPARS 2014 Annual Report.

In 2015 there was a new participating company; though the contribution to the overall tonnage of antimicrobials was minor to insignificant (personal communication Jean Szkotnicki-CAHI).

In 2015 there was a label claim extension for fluoroquinolones and tetracyclines.

¹⁷ Government of Canada. Canada Gazette. Regulations Amending the Food and Drug Regulations (Veterinary Drugs — Antimicrobial Resistance). Vol. 150, No. 27 — July 2, 2016. Available at: <http://www.gazette.gc.ca/rp-pr/p1/2016/2016-07-02/html/reg2-eng.php>. Accessed July 2016.

QUANTITIES OF ANTIMICROBIALS DISTRIBUTED FOR SALE FOR USE IN ANIMALS

KEY FINDINGS

The total quantity of antimicrobials reported by CAHI member companies, adjusted for populations and weights, was the highest reported since surveillance began in 2006. Relevant economic context provided by CAHI is that in 2015, individual animals (beef, pig, and poultry) were of high value and producers took steps to minimize risk of sickness by adopting antimicrobial use practices for treatment, control and prevention of disease.

In 2015, 1.8 million kg of antimicrobials were distributed for sale for use in animals by CAHI member companies. Approximately¹⁸, this reflects a 0% change relative to the 2006 total and an increase of 5% relative to the 2014 total (Table 3. 1). When the ionophores and chemical coccidiostats were removed, there was an 8% decrease since 2006 and 7% increase since 2014. Of the 1.8 million kg, 32% (570, 763/1,774,888 kg) were in Category IV; considered of low importance in human medicine (ionophores and chemical coccidiostats) (Table 3. 1 and Figure 3. 1).

The antimicrobial classes with the greatest relative increases in comparison to 2014 were the tetracyclines and fluoroquinolones (10% relative increase); a 60,235 and 77 kg increase, respectively.

Similar to other years, the predominant classes of antimicrobials distributed for sale in 2015 were the tetracyclines, ionophores, β-lactams (penicillins), "other antimicrobials"¹⁹, and the macrolides (based on kg of active ingredient; Table 3. 1 and Figure 3. 1).

There were provincial differences between the quantities of antimicrobials distributed for sale (Table 3. 2, Table 3. 3, and Figure 3. 2) and differences within provinces in the quantities distributed between years. Most provinces reported an increase in antimicrobials distributed for sale (by % of change) between 2014 and 2015; with the most notable increases occurring in Manitoba (16%), British Columbia (13%) and Ontario (8%). The exceptions were for Alberta and Nova Scotia which reported a 15% and 4% reduction, respectively. These differences between provinces could be related to different numbers and types of animals in each province, differences in disease pressure, or differences in antimicrobial use or other management practices. The quantities reported per province reflect the quantities distributed to veterinary clinics, feed mills, and over-the-counter outlets by CAHI member companies.

¹⁸ CAHI member companies occasionally restate their annual data which can impact the evaluation of trends over time. Every effort is made to ensure comparisons are made with the most up-to-date data available.

¹⁹ "Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

There may be subsequent re-distribution of antimicrobials across provincial borders after this point.

In 2015, the quantity of antimicrobials distributed for use in companion animals represented less than 1% of the total antimicrobials distributed for sale. Antimicrobials distributed for sale for use in companion animal were mostly cephalosporins, β-lactams (penicillins), and trimethoprim and sulfonamides (Table 3. 3 and Figure 3. 3). For production animals, the antimicrobials distributed for sale were mostly tetracyclines, ionophores and chemical coccidiostats, and β-lactams (penicillins) (Table 3. 3 and Table 3. 4).

Overall, antimicrobials are predominantly distributed for use in feed (85% of total kg) (Figure 3. 5). Since 2014 (data not shown), the increases in sales by route of administration (related to the 2014 totals) were increases in oral/topical (33%), feed (5%), and water (3%). The decreases in sales were for intra-mammary (11%) and injection (3%). The predominant classes of antimicrobials vary considerably across the routes of administration (Figure 3. 5 and Figure 3. 6).

In terms of the Canadian animal population, CIPARS conducted a review of historical animal population numbers, revised the historical numbers where new data had become available, harmonized the animal weights further for poultry (with the ESVAC approach), and added new stratifications where identified (see Chapter 5—Design and Methods). These changes were applied to all historical population data and the revised results are reported here. The animal biomass (otherwise known as the population correction unit [PCU]) in Canada has decreased over time from the highest point in 2006. Since 2006, there has been a 17% decline in the PCU and a 1% decline since 2014 (Figure 3. 7; using Canadian standard weights). Comparing the 2015 animal biomass to 2006 (Canadian standard weights), the respective declines in the PCU were as follows: cattle 24%, swine 10%, and sheep and goats 4%. Rabbits increased by 12%, fish increased by 9%, and poultry increased by 1%. Recent live horse data were not available at the time of writing.

For production animals, the total quantity of antimicrobials distributed for sale adjusted for populations and weights (mg/PCU) was 183 using European standard weights (156 using Canadian standard weights). This represents an increase of 8% since 2006 and an 8% increase since 2014 using ESVAC standard weights; a 10% and 8% respectively, using Canadian standard weights (Figure 3. 8). The mg/PCU for companion animals was 96.

For international comparison, the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), at the time of writing, had data available for 29 European countries for 2014²⁰. Comparing the most recent data (Canada 2015, ESVAC 2014), Canada ranked as 5th highest for PCU (with first rank being the country with the highest animal biomass); only lower than Germany, France, Spain, and the United Kingdom. When compared to the countries participating in the ESVAC network, for the mg/PCU, Canada was 25 out of 30

²⁰ European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, 2016. "Sales of veterinary antimicrobial agents in 29 European countries in 2014". (EMA/61769/2016). Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Report/2016/10/WC500214217.pdf. Accessed October 2016.

countries (Figure 3.9), when ranked from smallest to highest mg/PCU. It is critical to recognize that Canada's position would be further to the left on the figure (higher mg adjusted by populations and weights) if we could account for the currently unrecorded imports of antimicrobials which fall under own-use importation and imports of active pharmaceutical ingredients intended for further compounding. Also, in this comparison, the Canadian data includes numbers of live beef cows, which are not included as a separate category in the European data. With international comparison, that the structure and detail in the data for animal production classes available in the European datasets differ from the Canadian datasets (see Chapter 5—Design and Methods), hence this figure should be interpreted with caution.

NATIONAL-LEVEL ANTIMICROBIAL DISTRIBUTION DATA

Table 3. 1 Quantity of antimicrobials (kg) distributed in Canada for sale for use in animals, 2006–2015

Antimicrobial class aggregation	Quantity of active ingredient (kg)										Change (%) from 2006 to 2015	Change (%) from 2014 to 2015	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015			
Aminoglycosides	5,122	4,302	5,817	4,652	3,961	12,242	10,372	10,785	13,276	13,718	NA	NA	
Amphenicols	NA	NA	3,242	4,001	4,391						NA	NA	
β-Lactams (penicillins)	58,538	52,594	109,153	118,109	201,934	147,853	136,611	134,838	139,278	139,565	NA	0%	
Cephalosporins	702	850	NA	NA	NA	6,716	6,388	2,403	6,812	6,795	NA	NA	
Fluoroquinolones	591	443	411	377	381	519	406	469	782	860	45%	10%	
Ionophores, chemical anticoccidials, and arsenicals ^a	455,753	445,952									NA	NA	
Ionophores, chemical coccidiostats, arsenicals, and nitroimidazoles ^a			472,384	491,152	490,355	22,372	18,471	45,138	104,332	103,874	NA	NA	
Chemical coccidiostats ^a						433,332	473,595	311,652	462,476	466,888	NA	0%	
Ionophores ^a											NA	NA	
Lincosamides	67,825	55,872	41,222	44,137	46,373	43,256	51,027	54,784	60,006	65,646	-3%	9%	
Macrolides and pleuromutilins	136,497	118,725									NA	NA	
Macrolides, pleuromutilins, and bacitracins	NA	NA	210,869	204,169	170,154						NA	NA	
Macrolides	NA	NA	NA	NA	NA	108,858	98,622	93,870	112,340	114,186	NA	2%	
Other antimicrobials	143,029	146,880	32,706	21,339	26,757	130,899	129,614	125,511	125,178	128,144	NA	2%	
Tetracyclines	847,281	753,168	680,601	686,832	535,142	600,918	635,435	635,675	599,540	659,784	-22%	10%	
Trimethoprim and sulfonamides	50,789	38,961	59,166	57,596	48,221	70,454	58,716		63,367	69,255	75,427	NA	9%
Total	1,766,126	1,617,748	1,615,571	1,632,365	1,527,669	1,577,419	1,619,257	1,478,492	1,693,275	1,774,888	0%	5%	

See corresponding footnotes on the next page.

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NA = not applicable or not available.

Changes in percentage over time from 2006 to 2015 are relative to the quantities reported in 2006. Changes in percentage over time from 2014 to 2015 are relative to the quantities reported in 2014.

Values do not include antimicrobials imported under the 'own use' provision or imported as active pharmaceutical ingredients used in compounding.

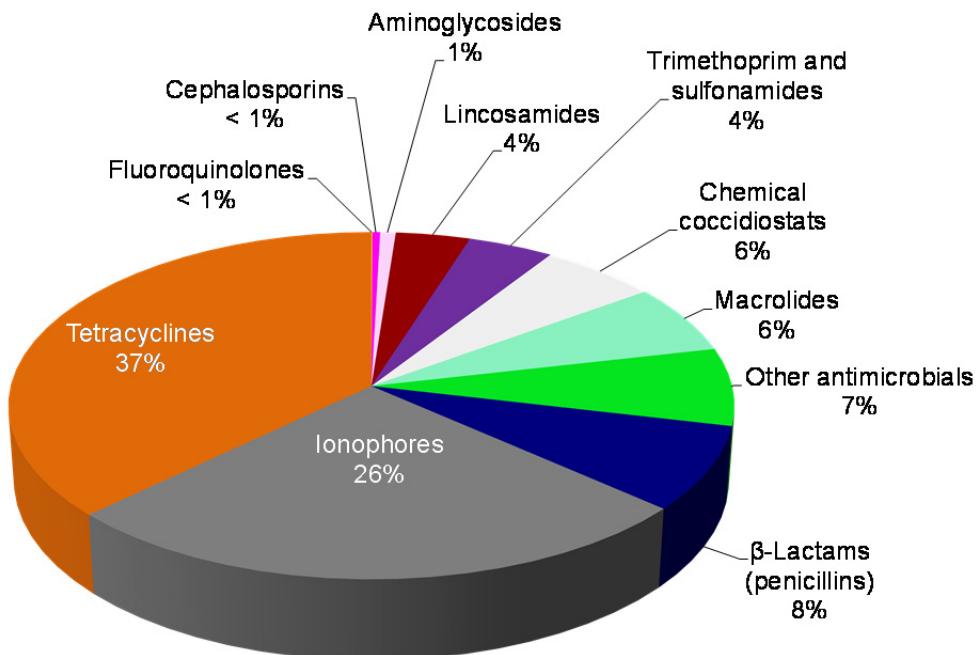
The inclusion of one new member company within CAHI has only a minor impact in terms of volume and does not explain the increase in quantities of antimicrobials distributed.

CAHI provides the information according to a "3 company accounting rule" established by CAHI to comply with the European Union and the United States' anti-competition regulations. CAHI added in some cases a "90% rule" to be sure not to infringe the regulations in the United States. These accounting rules can result in changes to the categorization of specific antimicrobials over time; hence within an antimicrobial category, columns with different colours should not be compared.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

^aThese antimicrobial classes are considered of low importance to human medicine (Category IV) according to the Veterinary Drugs Directorate.

Figure 3. 1 Percentages of the quantities (kg of active ingredient) of antimicrobials distributed in Canada for sale for use in animals, 2015



Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

Province abbreviations are defined in the Appendix.

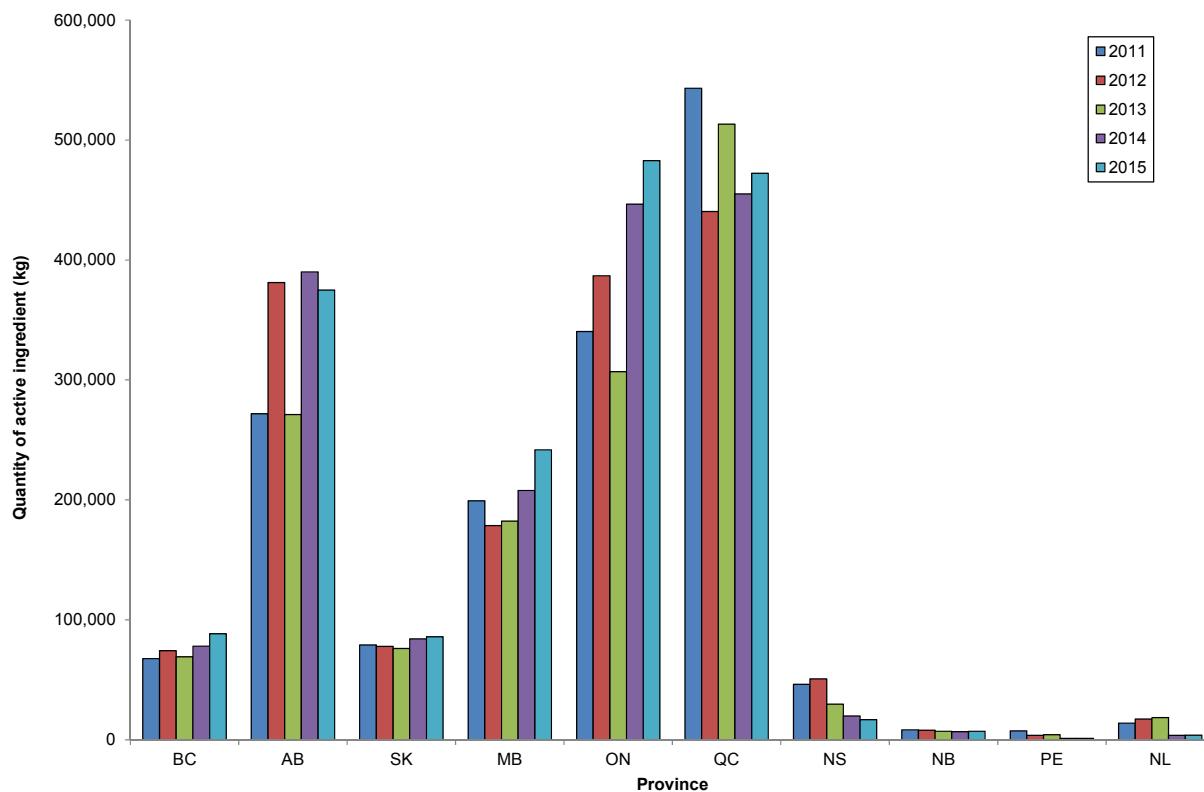
CAHI accounting rules can result in changes of antimicrobial categorizations over time. Please consult Table 3.1 to determine whether an appropriate comparison across years can be made for that antimicrobial class.

There may be subsequent distribution of antimicrobials across provincial borders after being distributed to the veterinary clinics.

Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

Figure 3. 2 Quantity of antimicrobials (kg of active ingredient) distributed for sale for use in animals by province, 2011–2015



Province	2011	2012	2013	2014	2015	Change (%) since 2011	Change (%) since 2014
BC	67,755	74,376	69,189	78,096	88,416	30	13
AB	271,788	381,193	271,106	390,011	374,867	38	-4
SK	79,099	77,971	76,132	84,163	85,824	9	2
MB	199,166	178,577	182,292	207,894	241,654	21	16
ON	340,483	386,917	306,886	446,535	482,774	42	8
QC	543,135	440,364	513,266	455,020	472,301	-13	4
NS	46,292	50,797	29,732	19,896	16,841	-64	-15
NB	8,329	7,959	7,180	6,775	7,195	-14	6
PE	7,465	3,781	4,164	1,134	1,148	-85	1
NL	13,907	17,322	18,544	3,751	3,868	-72	3
Total	1,577,419	1,619,257	1,478,492	1,693,275	1,774,888	13	5
				> 10% but < 20% increase	> 10% but < 20% decrease		
				≥ 20% but < 30% increase	≥ 20% but < 30% decrease		
				≥ 30% increase	≥ 30% decrease		

This figure does not account for provincial differences in numbers or types of animals.

Province abbreviations are defined in the Appendix.

There may be subsequent distribution of antimicrobials across provincial borders after being distributed to the veterinary clinics.

Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

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DISTRIBUTION BY ANIMAL TYPE**Table 3. 3 Quantity of antimicrobials (kg of active ingredient) distributed for sale for use in animals by province and animal type, 2015**

Animal type / province	Aminoglycosides	B-Lactams (penicillins)	Cephalosporins	Fluoroquinolones	Chemical coccidiostats	Ionophores	Lincosamides	Macrolides	Other antimicrobials	Tetracyclines	Trimethoprim and sulfonamides	Total
Production animal												
BC	666	11,309	249	83	16,374	11,977	103	606	10,955	32,584	2,482	87,389
AB	833	16,312	363	145	6,459	157,739	8,313	30,000	21,985	119,530	11,422	373,103
SK	837	3,760	88	5	3,584	31,542	3,116	3,953	5,606	29,058	3,832	85,381
MB	739	17,075	129	23	6,930	55,071	18,977	25,823	13,781	92,543	9,388	240,479
ON	4,388	54,785	802	208	25,861	120,366	19,269	30,294	41,097	153,971	27,256	478,298
QC	5,809	28,434	446	80	42,867	83,696	15,631	22,941	30,423	221,503	17,933	469,763
NS	181	1,486	58	13	1,188	4,560	56	472	2,424	5,691	512	16,642
NB	49	616	12	1	1	0	2	9	90	209	109	1,099
PE	107	1,232	37	2	160	256	24	88	137	4,666	357	7,066
NL	33	299	16	1	449	1,680	3	1	1,247	28	61	3,818
Total	13,644	135,309	2,200	562	103,874	466,888	65,493	114,186	127,746	659,784	73,352	1,763,039
Companion animal												
BC	4	356	519	44	0	0	0	0	34	0	70	1,027
AB	5	513	759	77	0	0	19	0	69	0	323	1,764
SK	5	118	184	3	0	0	7	0	17	0	108	442
MB	4	537	268	12	0	0	44	0	43	0	266	1,175
ON	24	1,723	1,674	110	0	0	45	0	128	0	771	4,475
QC	32	894	931	43	0	0	37	0	95	0	507	2,538
NS	1	47	122	7	0	0	0	0	8	0	14	198
NB	1	39	78	1	0	0	0	0	0	0	10	129
PE	0	19	26	0	0	0	0	0	0	0	3	49
NL	0	9	34	1	0	0	0	0	4	0	2	50
Total	74	4,256	4,595	298	0	0	153	0	398	0	2,075	11,849
Total (animal types combined)												
	13,718	139,565	6,795	860	103,874	466,888	65,646	114,186	128,144	659,784	75,427	1,774,888

Production animals include horses.

Province abbreviations are defined in the Appendix.

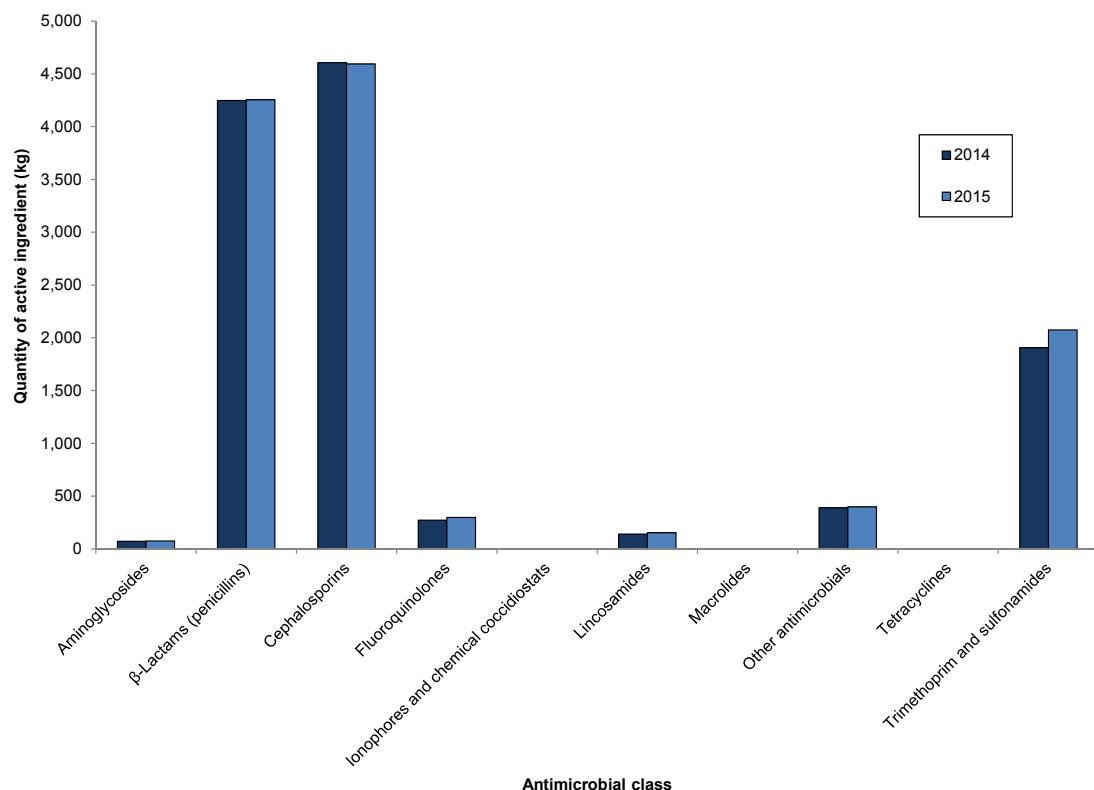
The attribution of antimicrobials sold in each province to the type of animal (companion animals vs. production animals) was based on multiplying a national average percentage of the antimicrobial sold for companion animals/production animals by the total reported for that province by the manufacturers.

Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

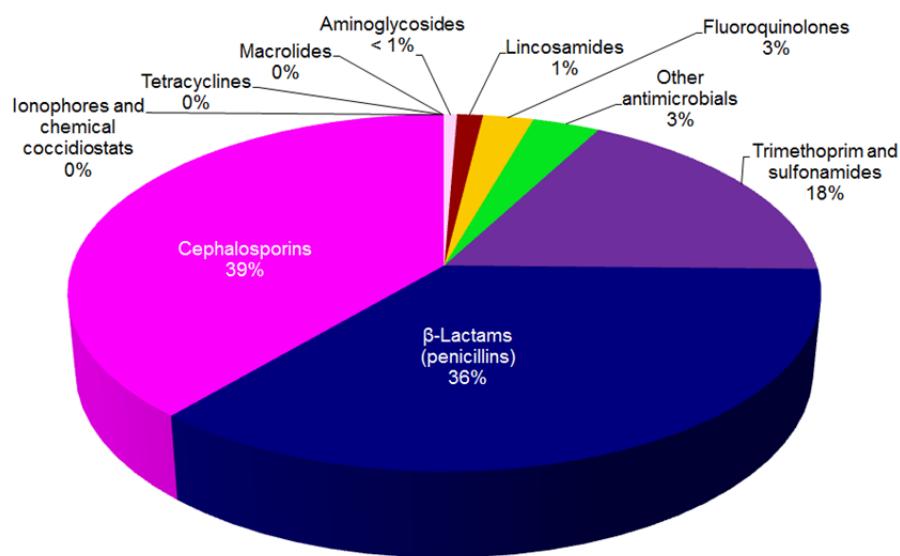
"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

Figure 3. 3 Quantity of antimicrobials (kg of active ingredient) distributed for use in companion animals over time and in 2015

a) Over time



b) 2015



See corresponding footnotes on next page.

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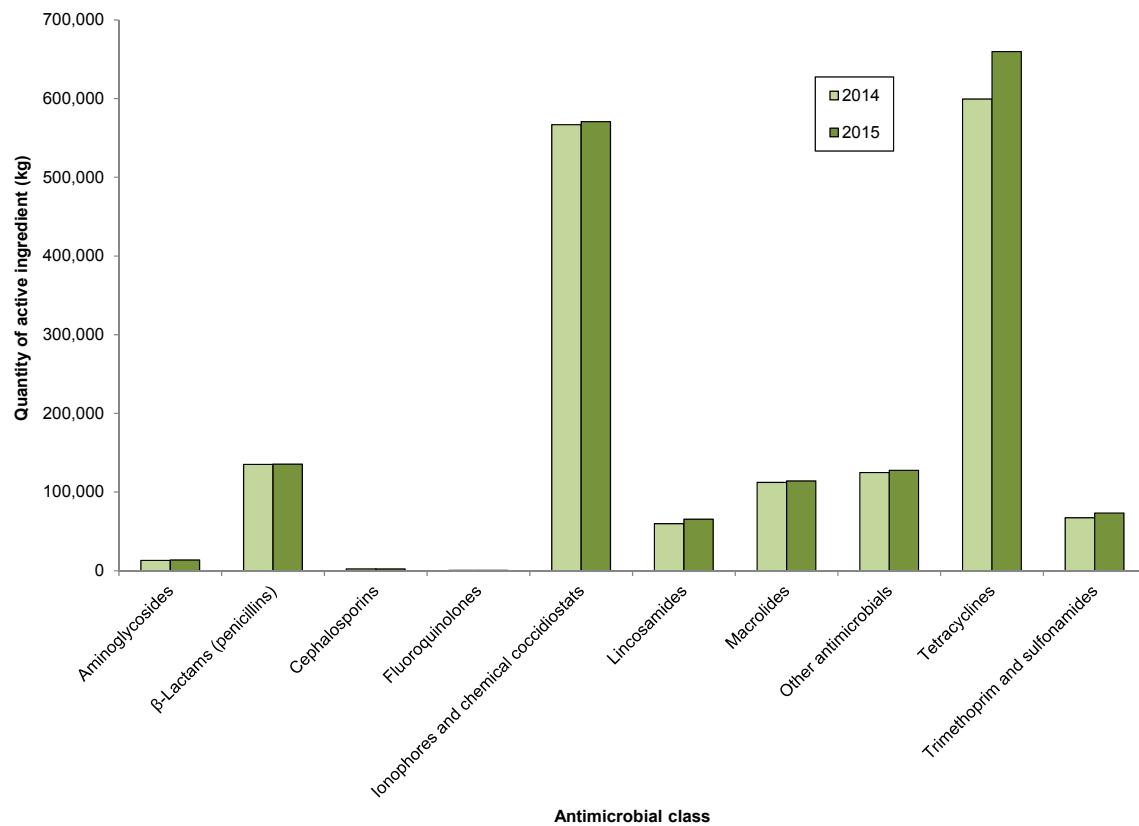
Antimicrobial sales were assigned to animal type according to label claim and in the situation where mixed species was indicated on the label, the manufacturer assigned the kg to either "Companion animal" or "Production animal".

Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

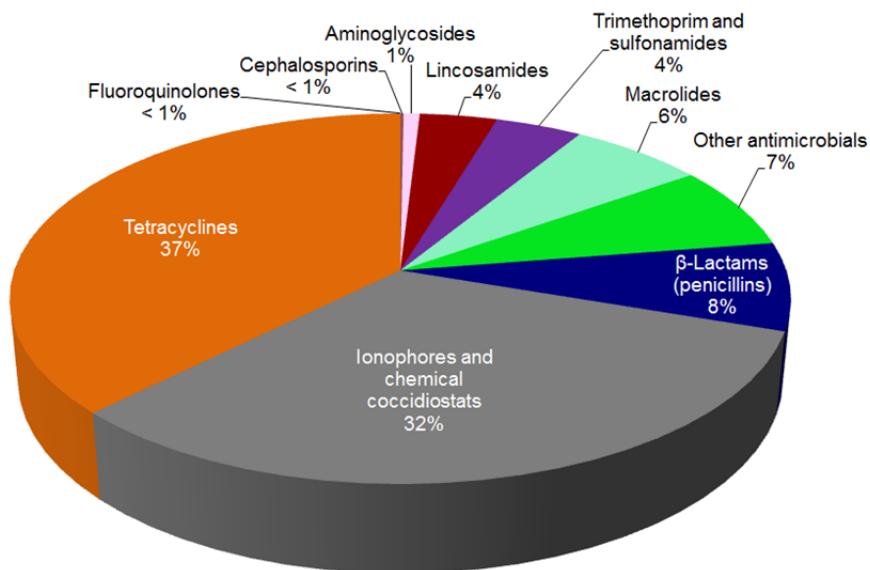
"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

Figure 3. 4 Quantity of antimicrobials (kg of active ingredient) distributed for use in production animals over time and in 2015

a) Over time



b) 2015



See corresponding footnotes on the next page.

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Note the differences in scale of the vertical axes between the companion animal figure (Figure 3. 3 a) and the production animal figure. Production animals include horses.

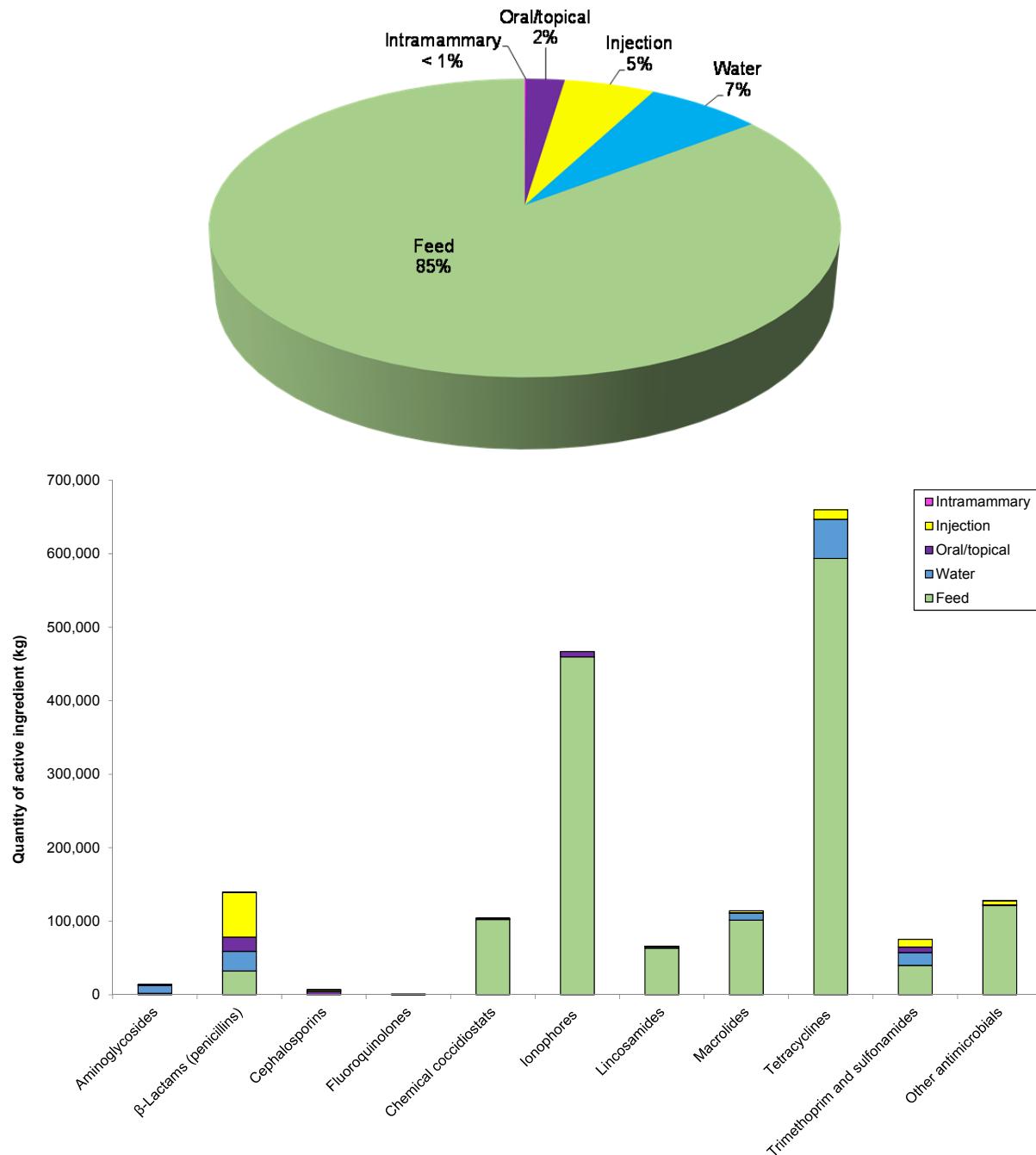
Antimicrobial sales were assigned to animal type according to label claim and in the situation where mixed species was indicated on the label, the manufacturer assigned the kg to either "Companion animal" or "Production animal".

Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

DISTRIBUTION BY ROUTE OF ADMINISTRATION

Figure 3. 5 Quantity of antimicrobials (% of total kg) distributed for use in animals, by route of administration and antimicrobial class, 2015

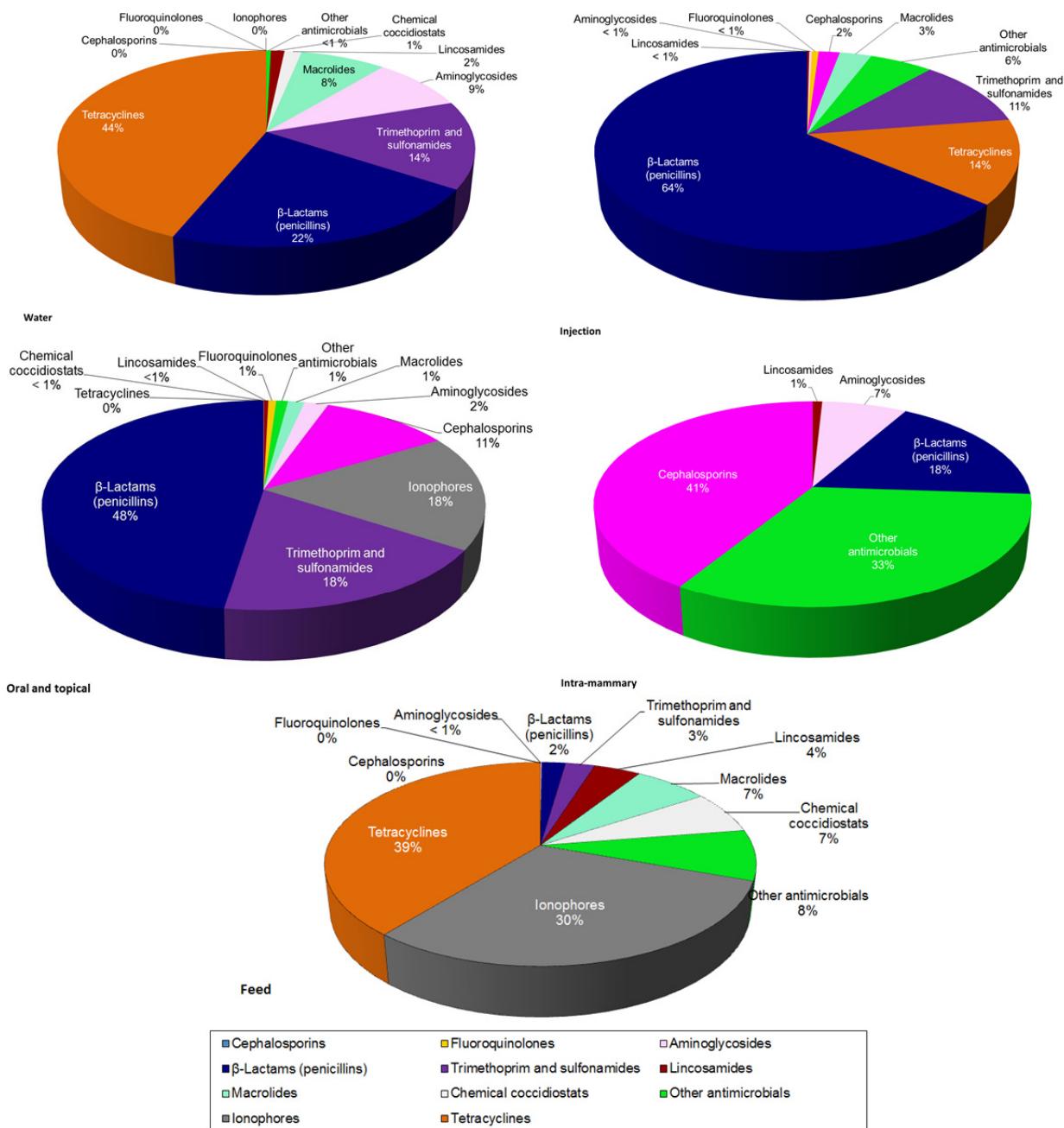


Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

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Figure 3. 6 Quantity of antimicrobials (% of total kg) distributed for use in animals, by route of administration, 2015



Values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

"Other antimicrobials" for 2015 included: avilamycin, bacitracins, bambermycin, chloramphenicol, chlorhexidine gluconate, florfenicol, fusidic acid, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, and virginiamycin.

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ANTIMICROBIAL DISTRIBUTION DATA AND ANIMAL BIOMASS IN CANADA—THE POPULATION CORRECTION UNIT (PCU) OVER TIME

Table 3. 4 Canadian population numbers and population correction unit (PCU), 2015

Animal species	Number of animals and/or kg fish	PCU _{ESVAC} (1,000 tonnes) ¹	PCU _{CAN} (1,000 tonnes) ²
Cattle	8,470,206	3,267	4,205
Swine	27,910,885	1,852	1,852
Poultry	630,619,552	749	856
Sheep and goats	1,322,607	56	56
Horses	963,500	385	482
Fish	187,374,000	187	187
Rabbit	669,873	1	1
Total production animals		6,498	7,639
Cats	7,000,000	28	28
Dogs	6,400,000	96	96
Total companion animals		124	124

For more detailed information on data sources and specific information on production stages, imports, exports, please see Table 3. 5.

The data used for live horses was from 2010 and cats/dogs from 2014; more recent data were unavailable.

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

CAN = Canadian.

Acknowledging the underlying sources of data structure the information differently, the PCU denominator was harmonized to the greatest extent possible with ESVAC²¹. The ESVAC denominator does not include beef cows, whereas in Canada, beef cows are a significant population and are included in Figure 3.7 and Figure 3.8.

^a PCU_{ESVAC} is based on ESVAC weights.

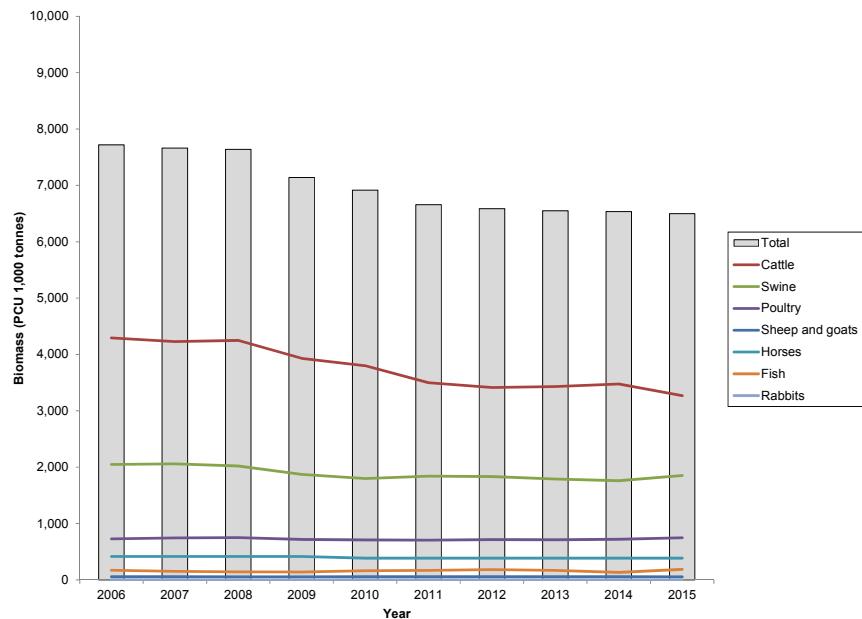
^b PCU_{CAN} is based on Canadian weights.

²¹ European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption. ESVAC Population correction unit template. Available at:

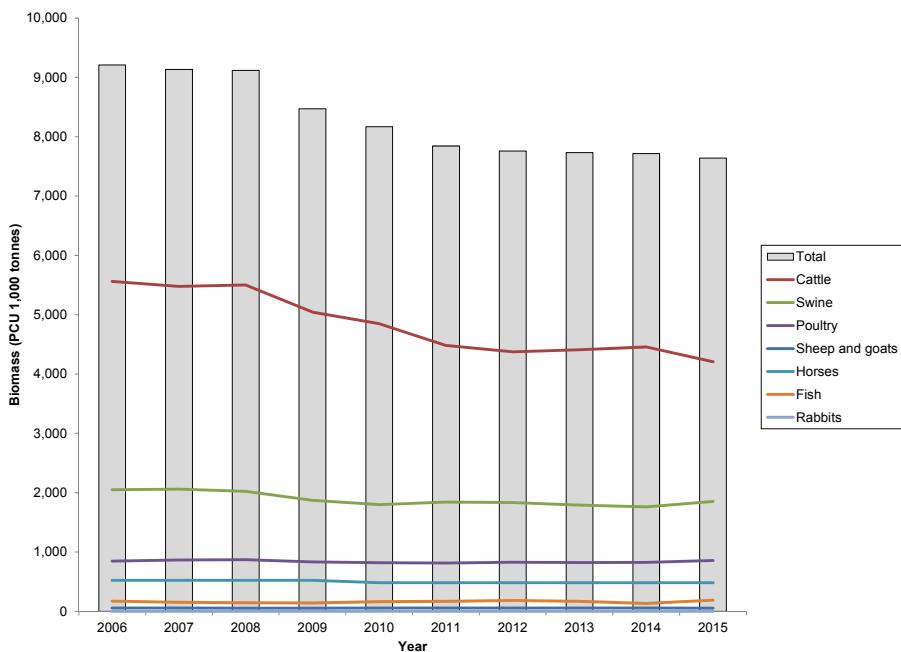
http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/document_listing/document_listing_000302.jsp. Accessed October 2016.

**Figure 3. 7 Biomass as measured by the population correction unit (PCU in 1,000 tonnes) over time;
using European Surveillance of Veterinary Antimicrobial Consumption production
classes and European weights and proposed Canadian weights, 2006–2015**

a) European weights



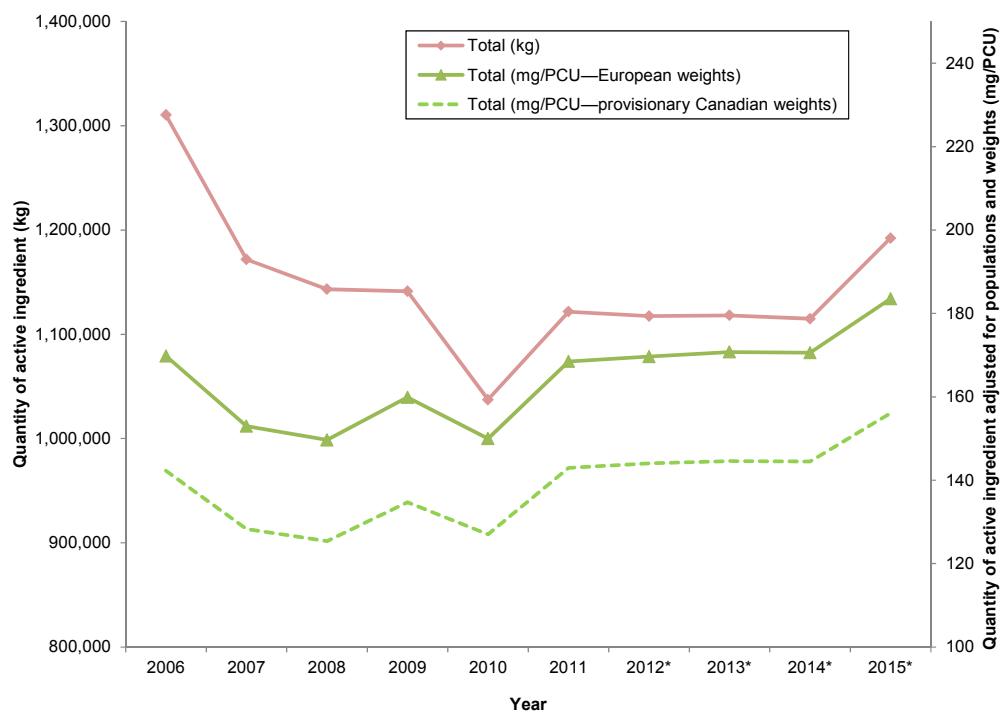
b) Proposed Canadian weights



See corresponding footnotes on the next page.

The data used for live horses was from 2010 and cats/dogs from 2014; more recent data were unavailable. Acknowledging the underlying sources of data structure the information differently, the PCU denominator was harmonized to the greatest extent possible with the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)²². ESVAC denominator does not include beef cows, whereas in Canada beef cows are a significant population and are included in both figures.

Figure 3. 8 Antimicrobials distributed for use in animals over time (kg of active ingredient and mg/PCU), 2006–2015



PCU = population correction unit.

The data used for live horses was from 2010 and cats/dogs from 2014; more recent data were unavailable.

Ionophores and chemical coccidiostats were excluded.

For the Canadian data, values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

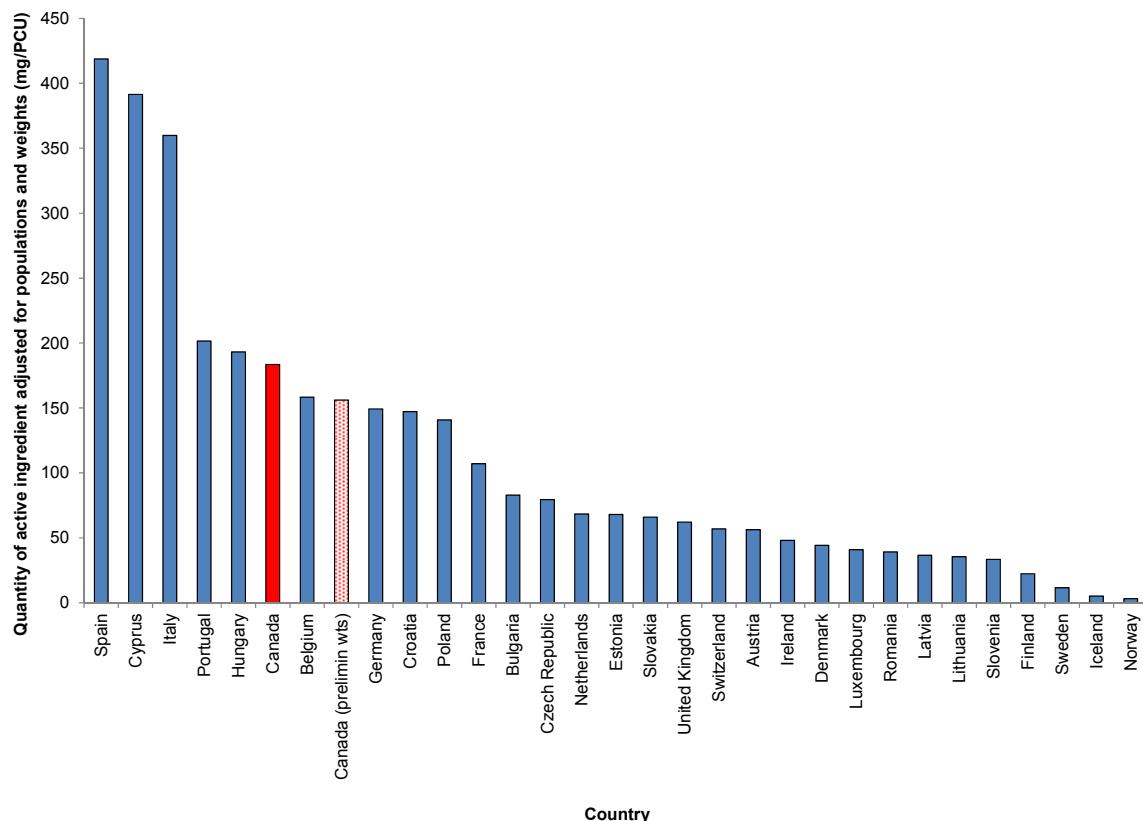
* Indicates data excluding antimicrobials sold for use in companion animals.

²² European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption. ESVAC Population correction unit template. Available at:

http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/document_listing/document_listing_000302.jsp. Accessed October 2016.

INTERNATIONAL DATA

Figure 3. 9 Sales of antimicrobials (adjusted by populations and weights) for Canada (2015) and countries participating in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) network (2014)



PCU = population correction unit.

The Canadian data used for live horses was from 2010 and cats/dogs from 2014; more recent data were unavailable.

Ionophores and chemical coccidiostats were excluded.

For the Canadian data, values do not include antimicrobials imported under the "own use" provision or imported as active pharmaceutical ingredients used in compounding.

The PCU denominator was harmonized to the greatest extent possible with the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)²³. ESVAC denominator does not include beef cows, whereas in Canada beef cows are a significant population and are included. The ESVAC approach excludes companion animal data from the numerator.

Data from all countries shown are using the same average weights at treatment. However, Canadian average weights in many production classes are heavier than European average weights. As per stakeholder request, based on preliminary analysis, the lighter red column for Canada indicates where Canada would rank if Canadian average weights at treatment were used in the calculations.

²³ European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, 2016. "Sales of veterinary antimicrobial agents in 29 European countries in 2014". (EMA/61769/2016). Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Report/2016/10/WC500214217.pdf. Accessed October 2016.

DETAILED DENOMINATOR DATA

Table 3. 5 Detailed information on population numbers, 2015

Animal species	Animal class/production class	Production stage	Number of animals	ESVAC average weight at treatment or standard weight for import/export (kg) ^a		PCU _{ESVAC} (1000 tonnes)	Canadian average weight at treatment or standard weight for import/export (kg) ^a	PCU _{CAN} (1000 tonnes)
				n	w ₁			
Cattle								
Cattle	Slaughter ^b		2,671,470					
Cow s	Slaughter		374,065	425	159	600	224	
Heifers	Slaughter		791,734	200	158	200	158	
Steers and bulls	Slaughter		1,505,670	425	640	425	640	
Calves	Slaughter ^b		225,530	140	32	249	56	
Slaughter cattle and calves	Export for slaughter to the US ^c		470,822	425	200	425	200	
Calves	Live cattle and calf international import for feeding or slaughter ^c		-32,192	140	-5	249	-8	
Feeder cattle and calves	Export for feeding to US ^c		349,177	140	49	249	87	
Beef cow s	On farm ^d		3,831,200	425	1,628	600	2,299	
Dairy cow s	On farm ^d		954,200	425	406	575	549	
Total			8,470,206		3,267		4,205	
Swine								
Finishers	Slaughter ^e		21,186,243	65	1,377	65	1,377	
All sw ine	International import ^f		-3,700	65	0	65	0	
Sw ine	Export for feeding to US ^g		4,360,421	25	109	25	109	
Sw ine	Export for slaughter to the US ^g		1,153,321	65	75	65	75	
Sow s and gilts (6 months and over)	On farm ^h		1,214,600	240	292	240	292	
Total			27,910,885		1,852		1,852	
Poultry								
Chickens (categories < 1.4 kg, 1.4 and < 2.7 kg, >2.7 kg)	Slaughter ⁱ		660,959,987	1	661	1.2	793	
Turkey (categories < 6.2 kg, > 6.2 but not > 8.5 kg, > 8.5 kg but not > 10.8 kg, > 10.8 kg but not > 13.3 kg, > 13.3 kg, mature turkeys)	Slaughter ⁱ		21,477,602	6.5	140	6.5	140	
Poultry (< 185 g)	Live poultry for import ^j		-31,371,957	1	-31	0.2	-6	
Poultry (> 185 g)	Live poultry for import ^j		-37,789,512	1	-38	2	-76	
Poultry (< 185 g)	Export ^j		16,524,572	1	17	0.2	3	
Poultry (> 185 g)	Export ^j		818,860	1	1	2	2	
Total			630,619,552		749		856	
Sheep and goats								
Sheep and lamb	Slaughter ^k		731,300	20	15	20	15	
Goats	Slaughter ^k		61,048	20	1	20	1	
Sheep and lamb	International import ^k		-6,554	20	0	20	0	
Sheep and lamb	International export ^k		5,513	20	0	20	0	
Ewes	On farm ^l		531,300	75	40	75	40	
Total			1,322,607		56		56	
Horses								
Horses	Living ^m		963,500	400	385	500	482	
Fish								
Finfish	Production (kg) ^o		151,031,000	N/A	151	N/A	151	
Shellfish	Production (kg) ^o		36,343,000	N/A	36	N/A	36	
Total			187,374,000		187		187	
Rabbits								
Rabbits	Slaughter ^p		669,873	1.4	1	1.4	1	
Total PCU for production animals								
Cats	N/A	N/A ^{q,r}	7,000,000	4	28	4	28	
Dogs	N/A	N/A ^{q,r}	6,400,000	15	96	15	96	
Total PCU for companion animals					124		124	

See corresponding footnotes on the next pages.

For horses, data on number of horses on farm were only reported for 2006 and 2010.

N/A = Not applicable.

- ^a As per European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), unless otherwise specified. ESVAC does not include beef cows. Beef cows are included here because they are a significant animal population in Canada.
- ^b Data from federal and provincial slaughter plants. Available at: <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=rR&pdctc=&r=105&menupos=1.02.06> and <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=rR&pdctc=&r=111&menupos=1.02.06>. Accessed May 12, 2016. These data were parsed into various animal categories (cows, heifers, steers and bulls) according to the % of these animals slaughtered at the federal level. Available at: <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=pR&pdctc=&r=109>. Accessed Oct. 30, 2016. This makes the assumption that the percentages of each animal category slaughtered at the provincial level are the same as at the federal level.
- ^c Supply comparison by species between Canada and the United States. Table 3. Available at: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/red-meat-and-livestock/red-meat-and-livestock-market-information/supply-sheets-by-species/supply-comparison-by-species-between-canada-and-the-united-states/?id=1415860000063>. Accessed April 21, 2016.
- ^d Table 003-0032. On all cattle operations. Data for January 1st. Available at: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0030032&&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=>. Accessed May 12, 2016.
- ^e Agriculture and Agri-Food Canada (Report A005C). Available at: <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?menupos=1.02.06&pdctc=&action=pR&LANG=EN&r=93>. Accessed May 26, 2016
- ^f Added for periods I and II. Statistics Canada (CANSIM 003-0102). Available at: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0030102&paSer=&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=>. Accessed May 24, 2016.
- ^g Swine export numbers - for feeding and slaughter. Available at: <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=rR&pdctc=&r=191>. Accessed Oct. 30, 2016.
- ^h Number of animals recorded on period II for 2015. Statistics Canada (CANSIM 003-0100). Available at: www.statcan.gc.ca/tables-tableaux/sum-som/I01/cst01/prim51a-eng.htm. Accessed May 24, 2016.
- ⁱ Live weight. For turkeys, mature birds were a separate designated category and were included. Agriculture and Agri-Food Canada (Poultry Slaughter - Report 001). Available at: <http://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=pR&r=1&pdctc=>. Accessed May 24, 2016.
- ^j Included all poultry. Agriculture and Agri-Food Canada (Poultry and Egg Trade Balance Report). Available at: <http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/poultry-and-eggs/poultry-and-egg-market-information-canadian-industry/imports-and-exports/statistics-canada-poultry-and-egg-trade-reports/2014-poultry-and-egg-trade-balance-reports/?id=1426000524082>. Accessed July 27, 2016.
- ^k Statistics Canada (CANSIM 003-0028). Available at: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0030028&tabMode=dataTable&srchLan=-1&p1=1&p2=9>. Accessed Sept. 29, 2016.
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- ⁿ Available at: http://www.equinecanada.ca/industry/index.php?option=com_content&view=section&id=103&Itemid=559&lang=en. Accessed May 24, 2016.

- ^o Table 003-0001. Available at:
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FARM SURVEILLANCE—BROILER CHICKENS

KEY FINDINGS

One hundred thirty-six sentinel flocks from 136 unique farms were surveyed in 2015 (pre-harvest questionnaire from one cohort flock was not received). Data collected pertains to only one cycle of broiler grow-out. Chicks were sourced from all major broiler Canadian Hatcheries Federation members ($n = 19$) across the country.

Fourteen broiler flocks (10%, 14/136) (Table 3. 6) or 9% of the broiler chicken population sampled (262,095/3,021,714)²⁴ reported not using antimicrobials during the grow-out period. These were flocks raised without antibiotics (RWA) (no use of any antibiotics, ionophores, and chemical coccidiostats).

Antimicrobials administered via feed represented the greatest route of administration/exposure in terms of frequency (90%, 121/135 flocks), mg/PCU (76%; 133/147 mg/PCU)²⁵ and nDDDvetCA/1,000 chicken-days (97%, 519/534 nDDDvetCA/1,000 chicken-days).

Provincial/regional and temporal variations in mg/PCU were noted. Overall, there was a national decrease in mg/PCU; however, the mg/PCU increased in Ontario by 10% (172 to 189 mg/PCU) (Figure 3. 10 and Table 3. 8). Provincial/regional and temporal variations in nDDDvetCA/1,000 chicken-days were also noted; an overall increase nationally (2%) and the nDDDvetCA/1,000 chicken-days increased in British Columbia by 6% (379 to 402 nDDDvetCA/1,000 chicken-days) and in Ontario by 8% (629 to 678 nDDDvetCA/1,000 chicken-days) (Figure 3. 13 and Table 3. 8).

Similar to 2014, 39% (53/136) of broiler producers reported that their chicks were medicated at the hatchery. Unlike the last 2 years of surveillance (2013 and 2014), there were no broiler producers that reported the use of Category I antimicrobials (by any route of administration) in 2015.

As in previous years, the most commonly used antimicrobial was bacitracin (51%, 69/136 flocks; 19%, 200/1,030 rations); the use of this antimicrobial accounted for 50% (75/148 mg/PCU) of the overall quantity of antimicrobials used in 2015.

Among the coccidiostats, the most frequently used was salinomycin (41%, 56/136 flocks; 15%, 158/1,030 rations). Coccidiostats were not routinely included in the mg/PCU and nDDDvetCA/1,000 chicken-days estimates for broilers. Flavophospholipids and other

²⁴ Biomass for 2015 surveillance year (3,021,714) = Total population at chick placement (3,095,424) minus half of the overall reported mortality at pre-harvest sampling day (73,710.50).

²⁵ mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating flocks) divided by PCU. Unless indicated, the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) of 1 kg/bird was used.

antimicrobials (low dose penicillin G use in feed) that has only growth promotion claim were also not included in the final estimates.

ADMINISTRATION IN FEED

Overall, 90% (122/135) of broiler chicken producers reported AMU in feed (Figure 3. 15); the antimicrobials used belonged to Categories II, III, and IV, and some drugs currently uncategorized by Health Canada's Veterinary Drugs Directorate.

There were 1,030 feed rations reported in the 2015 questionnaires and of these, 67 rations (7%) were unmedicated (Table 3. 7); a slight increase compared to 2014 (5%, 60/1,170 rations). Provincial/regional variations in the frequency of AMU were observed in 2015 (Figure 3. 16).

The following antimicrobial classes were used across the 4 provinces/region, similar to the previous years: streptogramins, bacitracins, ionophores/chemical coccidiostats and orthosomycins. These antimicrobial classes were used for treating enteric diseases such as necrotic enteritis (caused by *Clostridium perfringens*) and coccidiosis (*Eimeria* spp.). For most antimicrobial classes (except trimethoprim-sulfadiazine), disease prevention was the most frequently reported reason for use (Figure 3. 17). Similar to the previous surveillance years, trimethoprim-sulfadiazine was largely used for treatment (used for prevention in 1 flock) (Figure 3. 17) of avian pathogenic *Escherichia coli* (APEC), the classical causative agent of a variety of disease syndromes in broiler chickens including yolk sacculitis, septicemia, and respiratory disease, collectively known as colibacillosis²⁶.

There were provincial/regional variations in feed mg/PCU estimates (Figure 3. 18 and Figure 3. 19). The mg/PCU was relatively higher in Ontario (189 mg/PCU). The use of trimethoprim-sulfadiazine contributed to the overall mg/PCU levels in Ontario and Québec. There were no broiler chicken producers in British Columbia and the Prairies reporting the use of trimethoprim-sulfonamides; this resulted to a low to zero treatment usage via feed in these provinces/regions (Figure 3. 19).

Provincial/regional variations in the nDDDvetCA/1,000 chicken-days was also observed and largely similar to the previous metric (Figure 3. 20). The nDDDvetCA/1,000 chicken-days was relatively higher in Ontario (663 nDDDvetCA/1,000 chicken-days) and Québec (462 nDDDvetCA/1,000 chicken-days).

The number of broiler producers reporting AMU for growth promotion was relatively low in 2015 (1% bacitracins; 4% flavophospholipids) (Figure 3. 17); the quantity of antimicrobials for growth promotion contributed less than 1% of the total feed quantity in mg/PCU (Figure 3. 19).

²⁶ Nolan et al. Chapter 18. Colibacillosis. In Diseases of Poultry 13th Ed. Swayne et al (eds). John Wiley and Sons, Ames, Iowa, pp 751-805.

ADMINISTRATION IN WATER

Sixteen percent (21/135) of broiler chicken producers reported AMU in water (Table 3. 6); 13 of the 21 broiler chicken producers (62%) that used an antimicrobial in water consulted a veterinarian or a veterinary prescription was available.

In terms of quantity, antimicrobials administered via water contributed to 10% (14 of 147 mg/PCU) of the total quantity of antimicrobials used in 2015 (Figure 3. 12). There were no broiler chicken producers that reported the use of antimicrobials belonging to Category I in water in 2015. Unlike in feed medications, most antimicrobials used in water were used for the treatment of systemic diseases (6 antimicrobials); only 3 antimicrobials were used for disease prevention (Figure 3. 23).

In terms of the nDDDvetCA/1,000 chicken-days, antimicrobial use in water contributed only 3% to the total number (14/534 nDDDvetCA/1,000 chicken-days). In 2015, Québec had the highest nDDDvetCA/1,000 chicken-days in water (Figure 3. 26).

ADMINISTRATION *IN OVO* OR SUBCUTANEOUS INJECTION

No producers reported the use of ceftiofur in chicks at the hatcheries in 2015 in any province/region (Figure 3. 27 and Figure 3. 28).

Gentamicin use in British Columbia significantly increased from 12% (3/26) in 2013 to 40% (10/25) in 2015 but overall, the number of flocks treated at the hatchery in this province decreased from 73% (22/30) in 2013 to 40% (10/25) in 2015. The proportion of flocks medicated with lincomycin-spectinomycin in Québec was significantly higher ($p \leq 0.05$) compared to all other provinces/regions (Figure 3. 28).

The reported reason for any hatchery-level antimicrobial use was for disease prevention (Figure 3. 29). In 2015, the contribution of antimicrobials administered at the hatchery level relative to all route of administration was less than 1% (0.02 mg/PCU; 0.62 nDDDvetCA/1,000 chicken-days) (Table 3. 7).

SUMMARY OF ANTIMICROBIAL USE—ALL ROUTES OF ADMINISTRATION

Table 3. 6 Number of broiler flocks with reported antimicrobial use by route of administration, 2015

Antimicrobial use	Route of administration			
	Any route ^a n (%)	In ovo/subcutaneous n (%)	Feed n (%)	Water n (%)
Any antimicrobial use	122 (90)	53 (39)	121 (90)	21 (16)
No antimicrobial use ^b	14 (10)	85 (61)	14 (10)	114 (84)
Total flocks	136 (100)	136 (100)	135 (100)	135 (100)

In 2015, pre-harvest questionnaire from one flock was unavailable (no feed and water data).

^a Flocks with reported use of an antimicrobial class by feed, water, *in ovo*/subcutaneous, or any combination of these routes are included in each count.

^b These were antibiotic-free, organic and a conventional flock that were fed unmedicated feed rations and no medications in water throughout the grow-out period. The proportion of flocks sampled that were antibiotic-free (were not exposed to antibiotics and coccidiostats) and organic in certain province may not be representative of the volume of birds raised under these management practices in that participating province or nationally.

Table 3. 7 Frequency and quantity of antimicrobial use summary, 2015

Route of administration	Antimicrobial	Flocks n (%)	Ration n (%)	Days exposed median (min. ; max.) ^a	Level of drug median (min. ; max.) ^b	Quantity of antimicrobial active ingredient ^c	
						mg/PCU ^d	nDDDvetCA/1,000 chicken-days ^e
Feed							
II	Tylosin	20 (15)	49 (5)	8 (3 ; 18)	22 (22 ; 37)	7	7
	Penicillin G potassium	5 (4)	10 (1)	8 (5 ; 9)	20 (2 ; 20)	1	58
	Penicillin G procaine	13 (10)	20 (2)	9 (6 ; 18)	33 (20 ; 110)	7	37
	Virginiamycin	22 (16)	44 (4)	8 (1 ; 17)	22 (22 ; 26)	6	63
	Trimethoprim-sulfadiazine	15 (11)	15 (1)	7 (3 ; 15)	200 (200 ; 300)	20	87
III	Bacitracin	69 (51)	200 (19)	9 (1 ; 21)	55 (11 ; 110)	74	213
	Oxytetracycline	2 (1)	2 (0.2)	13 (11 ; 15)	440 (440 ; 440)	8	14
N/A	Avilamycin	46 (34)	93 (9)	8 (1 ; 17)	15 (15 ; 30)	10	98
Subtotal feed, VDD Cat. II, III and N/A						133	519
IV	Bambermycin	7 (5)	25 (2)	10 (1 ; 12)	2 (2 ; 2)	0.3	27
	Lasalocid	1 (1)	3 (0.3)	11 (6 ; 17)	75 (75 ; 75)	3	6
	Maduramicin	1 (1)	2 (0.2)	5 (3 ; 7)	5 (5 ; 5)	0	2
	Monensin	39 (29)	90 (9)	8 (2 ; 21)	99 (50 ; 117)	54	119
	Narasin	22 (16)	34 (3)	10 (1 ; 16)	70 (50 ; 70)	18	59
	Narasin nicarbazin	47 (35)	92 (9)	9 (3 ; 19)	80 (80 ; 80)	37	203
	Salinomycin	56 (41)	158 (15)	8 (2 ; 20)	60 (48 ; 100)	68	251
N/A	Clopidol	8 (6)	15 (1)	10 (7 ; 21)	125 (75 ; 125)	7	13
	Decoquinate	4 (3)	8 (1)	7 (4 ; 14)	30 (30 ; 30)	3	22
	Diclazuril	2 (1)	4 (0.4)	8 (5 ; 17)	2 (1 ; 3)	0	7
	Nicarbazin	47 (35)	86 (8)	8 (3 ; 17)	50 (16 ; 125)	22	37
	Robenidine	3 (2)	9 (1)	8 (7 ; 9)	33 (33 ; 33)	2	11
	Zoalene	3 (2)	4 (0.4)	7 (7 ; 12)	125 (125 ; 125)	1	1
Subtotal feed, VDD Cat. IV, N/A and other						215	815
Total feed		121 (90)	963 (93)			348	1,334
No AMU in feed		14 (10)	67 (7)				

See corresponding footnotes on the next page.

Table 3. 7 Frequency and quantity of antimicrobial use summary, 2015 (cont'd)

Route of administration	Antimicrobial	Flocks n (%)	No. of treatments n	Days exposed median (min. ; max.) ^a	Level of drug median (min. ; max.) ^b	Quantity of antimicrobial active ingredient ^c	
						mg/PCU ^d	nDDDvetCA/1,000 chicken-days ^e
Water							
II	Amoxicillin	3 (2)	4	5 (3 ; 6)	0.1 (0.1 ; 0.2)	2	5
	Penicillin G potassium	3 (2)	3	5 (3 ; 7)	0.2 (0.2 ; 0.2)	0.2	3
	Penicillin-streptomycin	6 (4)	6	5 (3 ; 8)	0.1 (0.02 ; 0.1)	5	3
III	Sulfamethazine	3 (2)	3	5 (2 ; 6)	1.0 (1.0 ; 1.0)	5	1
	Sulfaquinoxaline	2 (1)	2	3 (2 ; 3)	0.3 (0.3 ; 0.4)	1	0.5
	Sufaquinoxaline-pyrimethamine	2 (1)	2	2 (2 ; 2)	0.2 (0.2 ; 0.2)	1	10
	Oxytetracycline-neomycin	1 (1)	1	4 (4 ; 4)	0.3 (0.3 ; 0.3)	0.3	1
	Tetracycline	1 (1)	1	4 (4 ; 4)	0.1 (0.1 ; 0.1)	0.2	0.2
Subtotal water (excludes antiprotozoals)		21 (16)	22			14	14
Total water (includes antiprotozoals)		21 (16)	22			15	22
No AMU in water		114 (84)					
Injection							
I	Ceftiofur	0 (0)			Not used	0	0
	Gentamicin	13 (10)			0.2	< 0.1	0.05
	Lincomycin-spectinomycin	40 (29)			0.75	0.2	0.55
	Total injection	53 (39)				0.2	0.60
No AMU via injection		83 (61)					
Overall, excludes coccidiostats/antiprotozoals and other^f						147	534
Overall, with coccidiostats/antiprotozoals and other						364	1,357

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report). AMU = antimicrobial use.

Combination antimicrobials include the values for both antimicrobial components. "Other" antimicrobials include drugs labelled only for growth promotion.

Grey shaded areas = No data or calculations/values are not applicable for broilers.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler (mg_{drug}/kg_{animal}).

^a Days exposed are by ration (not full grow-out) or 1 course of water treatment.

^b Level of drug is in grams/tonne of feed or grams/liter of drinking water. In water, "grams" is the inclusion rate multiplied by the concentration of the drug in that product. In chicks or hatching eggs, level of drug is in milligrams per chick or hatching egg, as reported by the veterinarian/producer.

^c Total quantity of antimicrobials was calculated based on feed or water consumed (feed and water were estimated based on breed standards).

^d mg/PCU = mg (total milligrams of active ingredient consumed by participating flocks) divided by PCU.

^e nDDDvetCA/1,000 chicken-days = number of Defined Daily Doses for animals (pertains to the quantity of antimicrobials adjusted for DDDvetCA)/1,000 chicken-days (adjusted for population and days in the grow-out period).

^f Final mg/PCU excludes coccidiostats and flavophospholipids and final number of DDDvetCA/1,000 chicken-days exclude coccidiostats, flavophospholipids and other antimicrobials (growth promotion is the only labelled indication for use, e.g., low dose penicillin G in feed).

Table 3. 8 Production, biomass and quantity of antimicrobial use summary by province/region, 2013–2015

Province/ region	Year	Pre-harvest weight	Age sampled	Numerator ^a	Denominator		mg/PCU			nDDDvetCA/ 1,000 CD	Percent change ^d
		Mean	Mean	Active ingredient mg	Broiler weight _{EU} ^b kg	Broiler weight _{CA} ^c kg	mg/PCU _{EU}	mg/PCU _{CA}	% change ^d		
British Columbia	2013	1.9	33	54,261,569	522,525	627,030	104	87		482	
	2014	1.9	33	67,501,580	650,756	780,907	104	86		379	
	2015	2.0	33	54,447,865	592,652	711,182	92	77	-11	402	6
Prairies	2013	1.7	33	58,408,347	453,936	544,723	129	107		481	
	2014	1.9	34	153,398,813	910,594	1,092,713	168	140		447	
	2015	1.9	34	95,772,902	746,106	895,327	128	107	-24	424	-5
Ontario	2013	2.4	38	132,209,361	740,183	888,220	179	149		687	
	2014	2.2	36	172,264,675	999,661	1,199,593	172	144		629	
	2015	2.4	38	227,838,035	1,204,851	1,445,821	189	158	10	678	8
Québec	2013	1.9	33	80,394,607	581,995	698,394	138	115		633	
	2014	2.0	33	109,661,081	736,017	883,220	149	124		595	
	2015	1.8	33	68,033,382	491,834	590,200	138	115	-7	468	-21
National	2013	2.0	34	325,273,884	2,298,639	2,758,367	142	118		590	
	2014	2.0	34	502,826,150	3,297,028	3,956,433	153	127		523	
	2015	2.1	35	446,092,183	3,035,442	3,642,530	147	122	-4	534	2

The Prairies is a region including the provinces of Alberta and Saskatchewan.

mg/PCU = mg (total milligrams of active ingredient consumed by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption. CD = chicken-days.

nDDDvetCA/1,000 chicken-days = number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials adjusted for DDDvetCA)/1,000 chicken-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler (mg_{drug}/kg_{animal}).

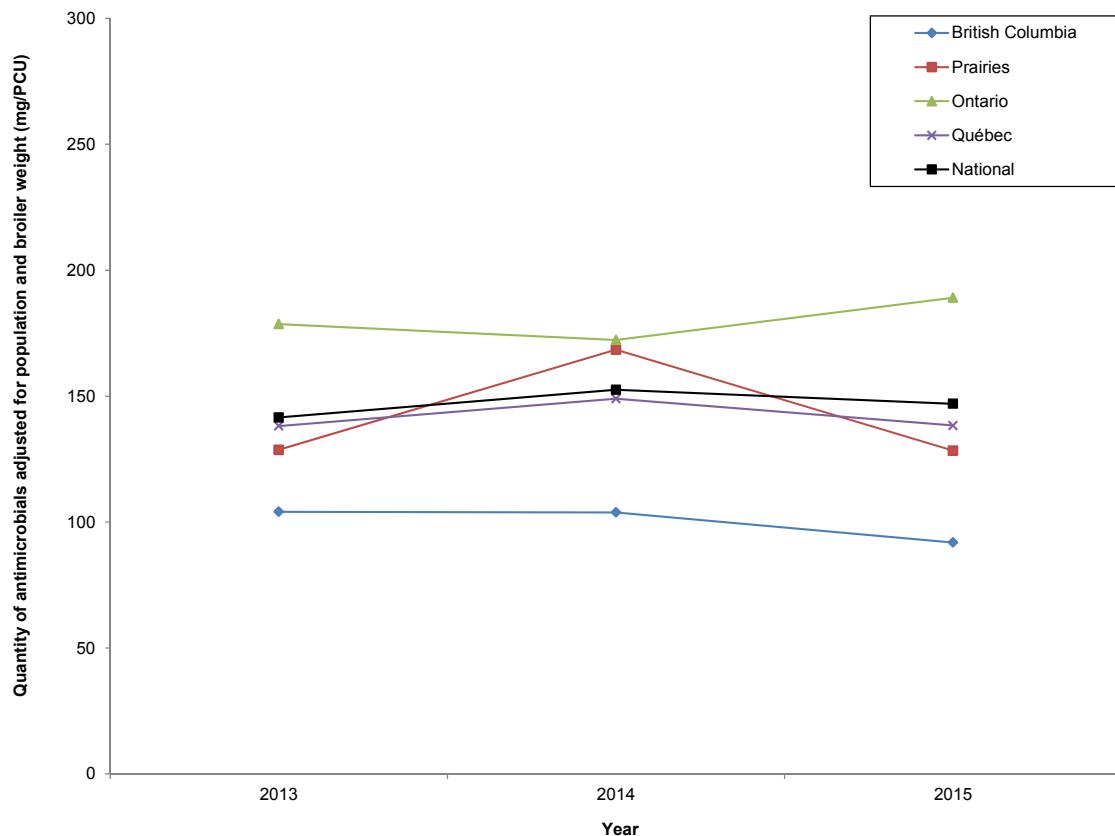
^a Includes only the provinces/regions surveyed and combines the quantity of antimicrobials used in feed, water and injection excluding coccidiostats, antiprotozoals and flavophospholipids.

^b Biomass, European weight (total flock population x ESVAC standard weight of 1 kg bird).

^c Biomass, Canadian weight (total flock population x Canadian weight of 1.2 kg bird).

^d Difference between 2015 and 2014 (applies to both mg/PCU_{EU} and mg/PCU_{CA}).

Figure 3. 10 Quantity of antimicrobials used in all routes of administration, adjusted for population and broiler weight (mg/PCU) by province/region, 2013–2015



Ionophores, chemical coccidiostats and flavophospholipids used in feed and antiprotozoals used in water (e.g., pyrimethamine, a diaminopyrimidine) were excluded in the estimates above.

mg/PCU = mg (total milligrams of active ingredient consumed by participating flocks) divided by PCU.

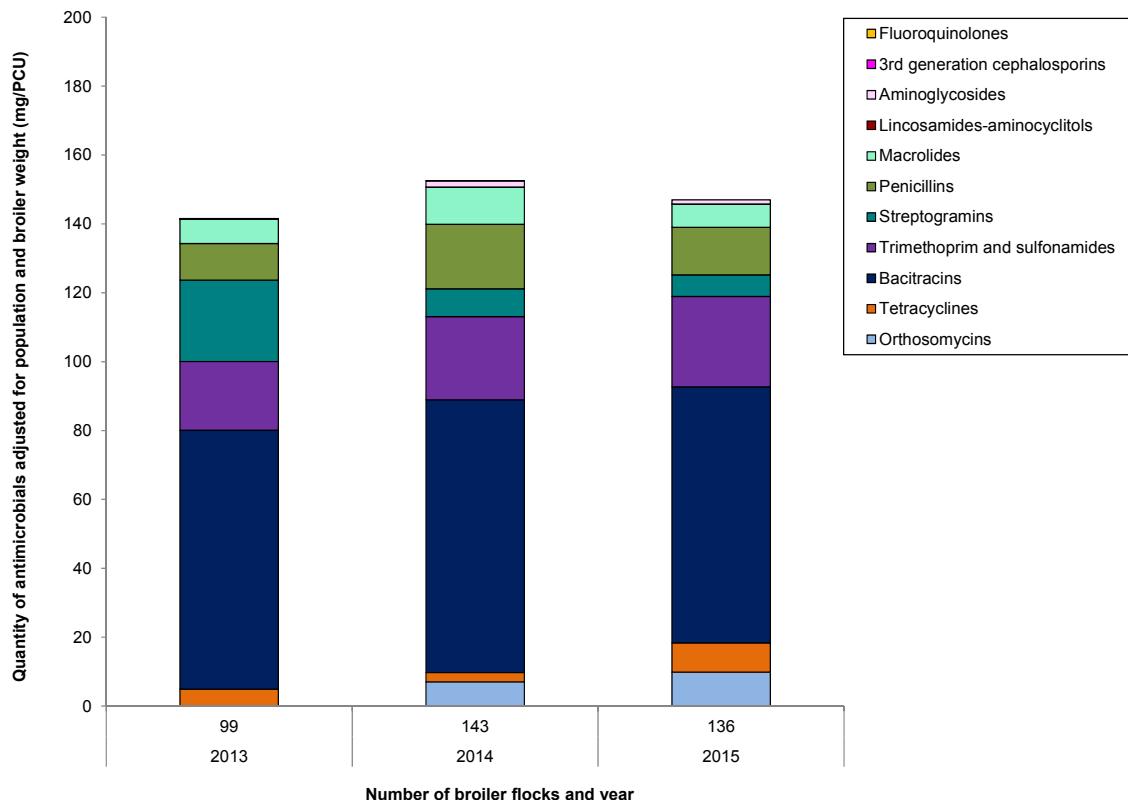
PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

National pertains to all provinces/regions that participated in the survey.

Figure 3. 11 Quantity of antimicrobials used in all routes of administration, adjusted for population and broiler weight (mg /PCU), 2013–2015



Year	2013 99	2014 143	2015 136
Number of flocks			
Antimicrobial class			
I			
Fluoroquinolones	< 0.1	0	0
3rd generation cephalosporins	< 0.1	< 0.1	0
II			
Aminoglycosides	< 0.1	2	1
Lincosamides-aminocyclitols	< 0.1	< 1	< 1
Macrolides	7	11	7
Penicillins	11	19	14
Streptogramins	24	8	6
Trimethoprim and sulfonamides	20	24	26
III			
Bacitracins	75	79	74
Tetracyclines	5	3	8
N/A Orthosomycins	0	7	10
Subtotal	142	153	147
IV			
Flavophospholipids	< 1	0	< 1
Ionophores	171	168	179
N/A Chemical coccidiostat	50	45	35
Diaminopyrimidines	1	1	1
Subtotal (not in figure)	221	213	215
Total	363	366	362

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

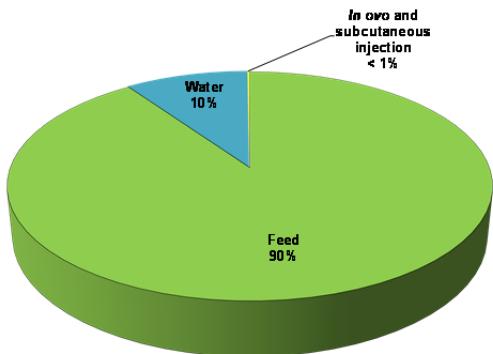
mg/PCU = mg (total milligrams of active ingredient consumed by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

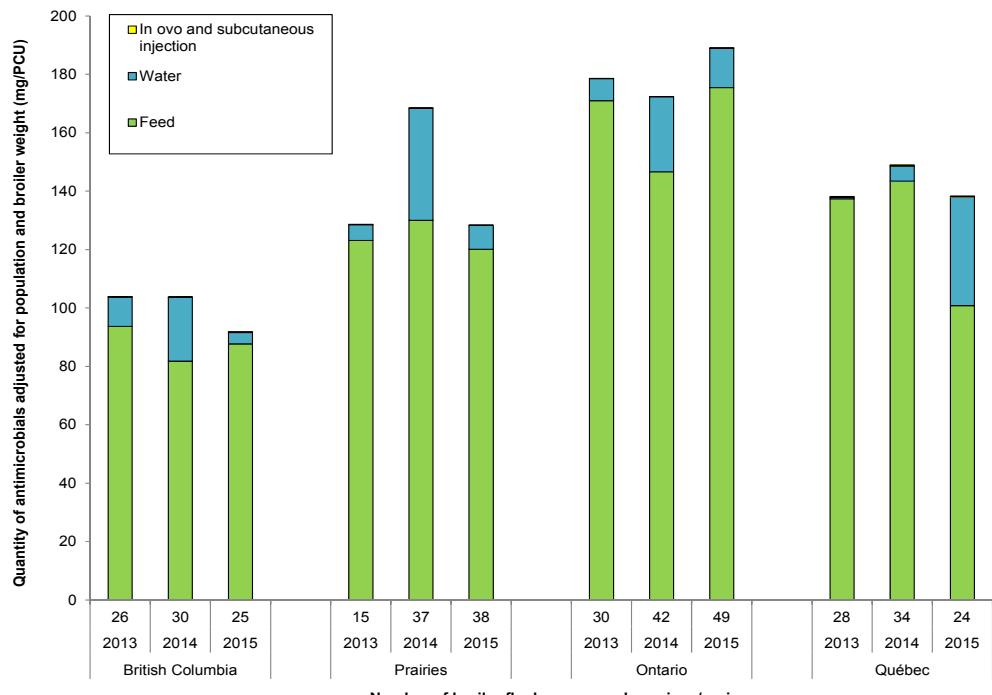
ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

Figure 3. 12 Quantity of antimicrobials, adjusted for population and broiler weight (mg/PCU) in 2015 and by province/region, 2013–2015

a) 2015



b) By province/region



Number of broiler flocks, year, and province/region															
Province/region			British Columbia			Prairies			Ontario			Québec			
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	26	30	25	15	37	38	30	42	49	30	42	49	28	34	24
Route of administration															
Feed	94	82	88	123	130	120	171	147	175	137	143	101			
Water	10	22	4	5	38	8	8	26	13	1	5	37			
In ovo and subcutaneous injections	0.1	0.1	0.3	0.1	< 0.1	0.1	0.1	< 0.1	0.2	0.3	0.4	0.4			
Total	104	104	92	129	168	128	179	172	189	138	149	138			

Ionophores, chemical coccidiostats and flavophospholipids used in feed and antiprotozoals used in water (e.g., pyrimethamine, a diaminopyrimidine) were excluded in the estimates above.

mg/PCU = mg (total milligrams of active ingredient consumed by participating flocks) divided by PCU.

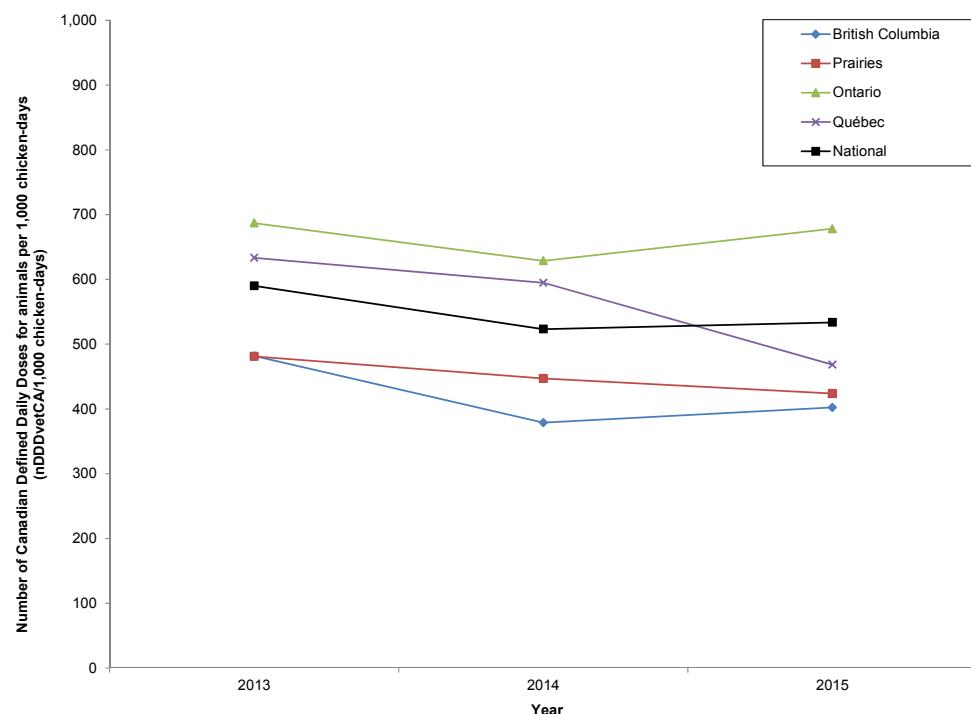
PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

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

**Figure 3. 13 Number of Canadian Defined Daily Doses for animals per 1,000 chicken-days
(nDDDvetCA/1,000 chicken-days) for all routes of administration, by province/region, 2013–2015**



Year Province/region	2013	2014	2015
British Columbia	482	379	402
Prairies	481	447	424
Ontario	687	629	678
Québec	633	595	468
National	590	523	534

Ionophores, chemical coccidiostats and flavophospholipids used in feed and antiprotozoals used in water (e.g., pyrimethamine, a diaminopyrimidine) were excluded in the estimates above.

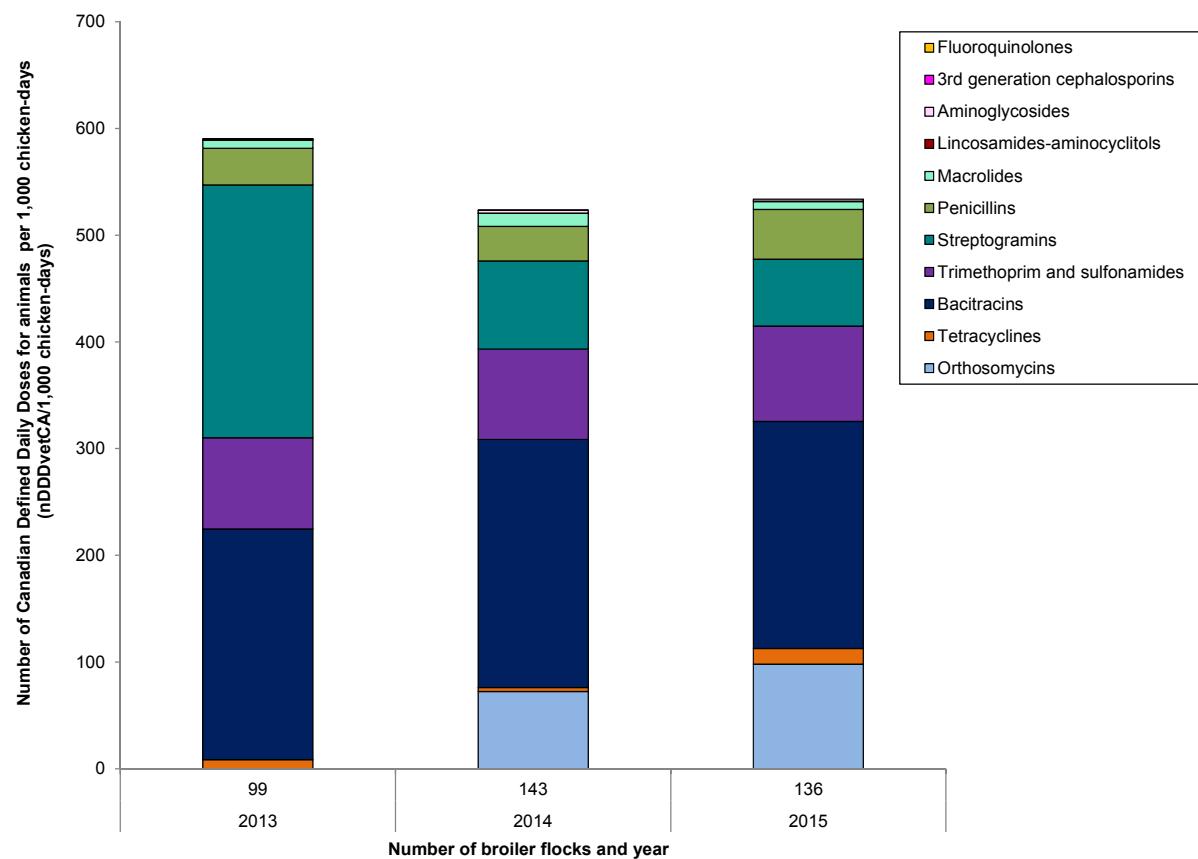
nDDDvetCA/1,000 chicken-days = number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials adjusted for DDDvetCA)/1,000 chicken-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

National pertains to all provinces/regions that participated in the survey.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 14 Number of Canadian Defined Daily Doses for animals per 1,000 chicken-days (nDDDvetCA/1,000 chicken-days) for all routes of administration, 2013–2015



Year	2013	2014	2015
Number of flocks	99	143	136
Antimicrobial class			
I Fluoroquinolones	< 0.1	0	0
3 rd generation cephalosporins	1	0.1	0
Aminoglycosides	< 0.1	2	2
Lincosamides-aminocyclitols	0.3	0.3	0.5
II Macrolides	8	12	7
Penicillins	34	32	47
Streptogramins	237	83	63
Trimethoprim and sulfonamides	85	85	89
III Bacitracins	216	232	213
Tetracyclines	9	4	15
N/A Orthosomycins	0	72	98
Subtotal	590	523	534
II Other antimicrobials	0	123	58
IV Flavophospholipids	16	0	27
Ionophores	606	596	639
N/A Chemical coccidiostats	105	113	90
Diaminopyrimidines	7	6	9
Subtotal (not in figure)	734	837	823
Total	1,324	1,361	1,357

See corresponding footnotes on the next page.

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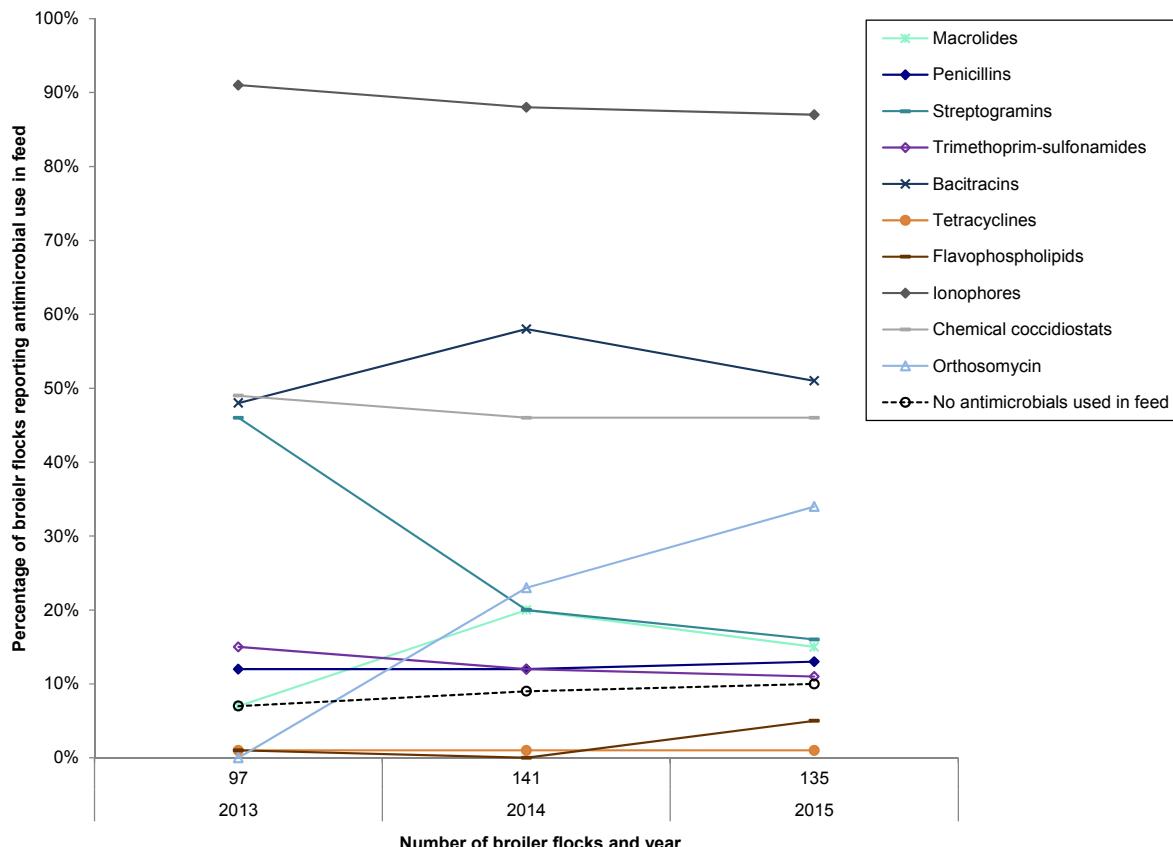
Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report). Ionophores, chemical coccidiostats and flavophospholipids used in feed and antiprotozoals used in water (e.g., pyrimethamine, a diaminopyrimidine) were excluded in the estimates above.

nDDDvetCA/1,000 chicken-days = number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials adjusted for DDDvetCA)/1,000 chicken-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligram per kilogram broiler weight ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

ANTIMICROBIAL USE IN FEED—FREQUENCY AND PRIMARY REASONS FOR USE

Figure 3. 15 Percentage of broiler flocks reporting antimicrobial use in feed, 2013–2015



Year Number of flocks	2013 97	2014 141	2015 135
Antimicrobial class			
Macrolides	7%	20%	15%
Penicillins	12%	12%	13%
Streptogramins	46%	20%	16%
Trimethoprim-sulfonamides	15%	12%	11%
Bacitracins	48%	58%	51%
Tetracyclines	1%	1%	1%
Flavophospholipids	1%	0%	5%
Ionophores	91%	88%	87%
Chemical coccidiostats	49%	46%	46%
Orthosomycin	0%	23%	34%
No antimicrobials used in feed	7%	9%	10%

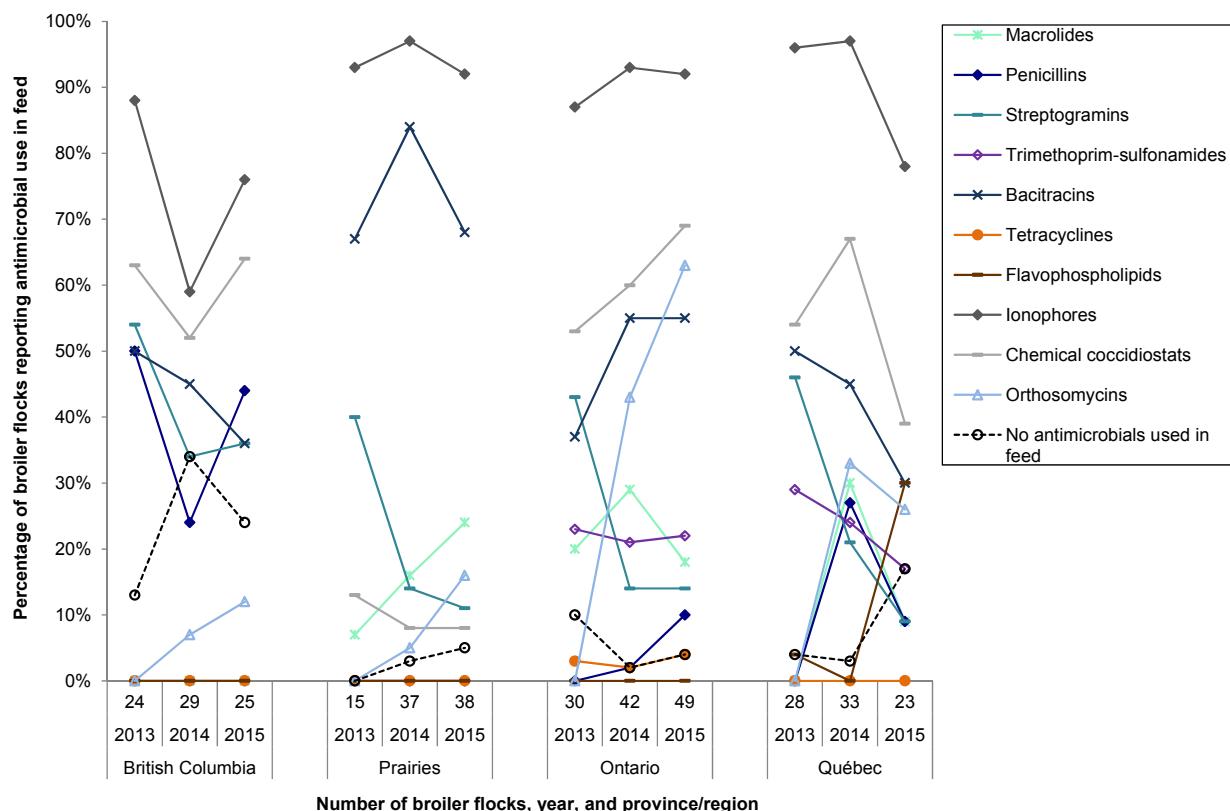
Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

Numbers per column may not add up to 100% as some flocks may have used an antimicrobial more than once or used multiple antimicrobials throughout the grow-out period.

For the temporal analyses, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences ($P \leq 0.05$) for a given antimicrobial.

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Figure 3.16 Percentage of broiler flocks reporting antimicrobial use in feed by province/region, 2013–2015.



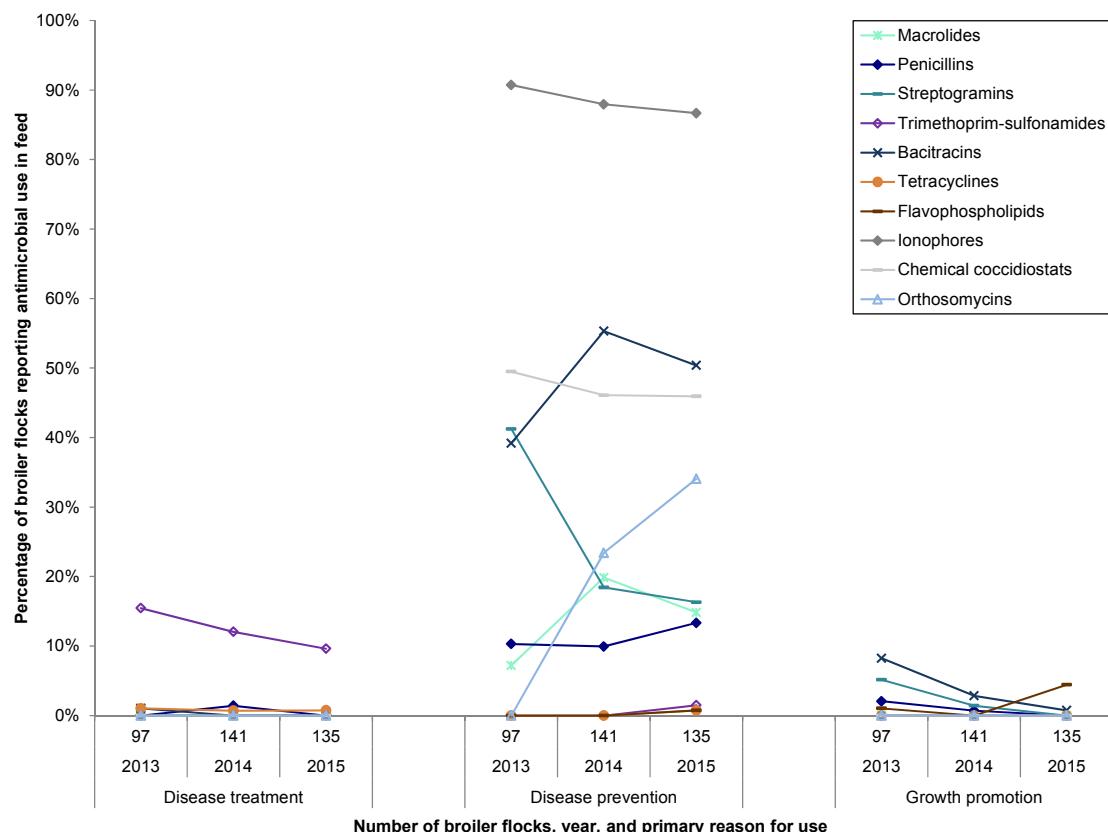
Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

Numbers per column may not add up to 100% as some flocks may have used an antimicrobial more than once or used multiple antimicrobials throughout the grow-out period.

For the temporal analyses within province/region, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3.17 Percentage of broiler flocks reporting antimicrobial use in feed by primary reason for use, 2013–2015



Primary reasons for use	Disease treatment			Disease prevention			Growth promotion		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Year	97	141	135	97	141	135	97	141	135
Number of flocks	97	141	135	97	141	135	97	141	135
Antimicrobial class									
II	Macrolides	0%	0%	0%	7%	20%	15%	0%	0%
II	Penicillins	0%	1%	0%	10%	10%	13%	2%	1%
II	Streptogramins	0%	0%	0%	41%	18%	16%	5%	1%
II	Trimethoprim-sulfonamides	15%	12%	10%	0%	0%	1%	0%	0%
III	Bacitracins	1%	0%	0%	39%	55%	50%	8%	3%
III	Tetracyclines	1%	1%	1%	0%	0%	1%	0%	0%
IV	Flavophospholipids	0%	0%	0%	0%	0%	1%	1%	0%
IV	Ionophores	0%	0%	0%	91%	88%	87%	0%	0%
N/A	Chemical coccidiostats	0%	0%	0%	49%	46%	46%	0%	0%
N/A	Orthosomycins	0%	0%	0%	0%	23%	34%	0%	0%

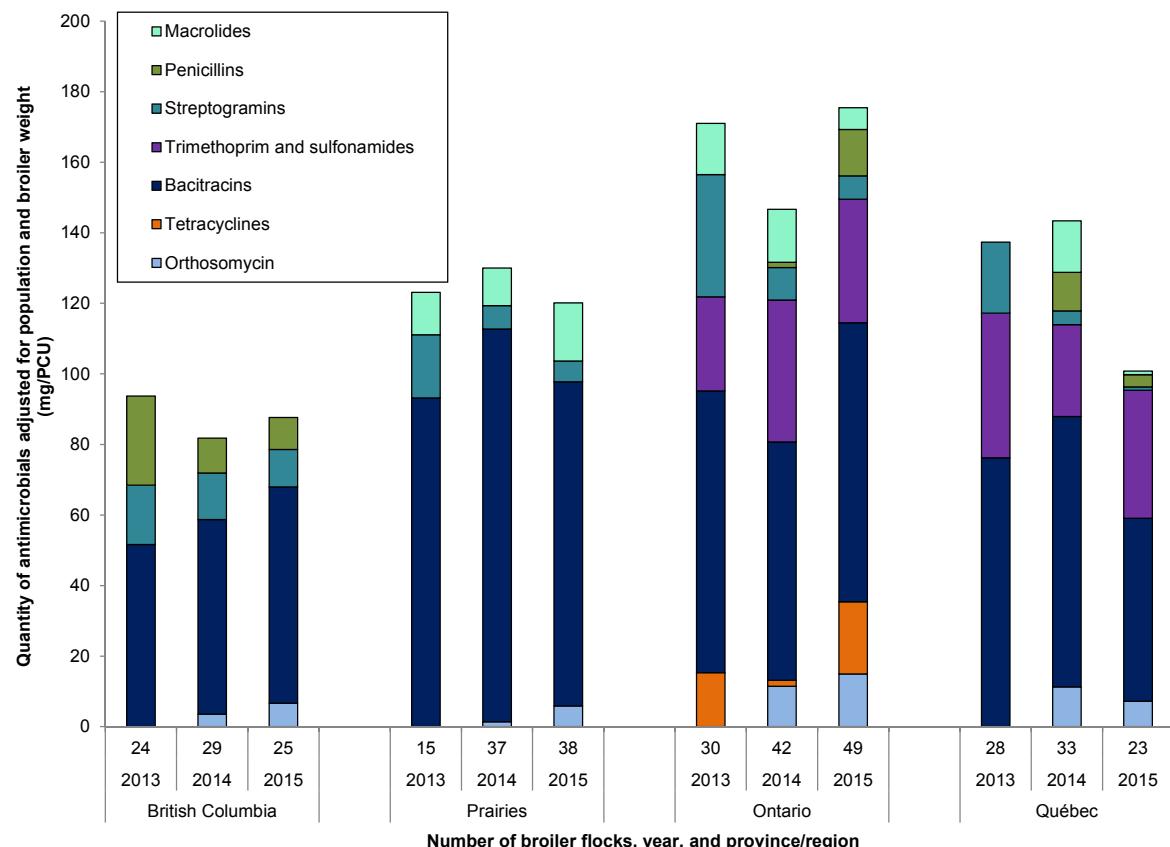
Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

Ionophores and chemical coccidiostats are listed in Table 3.7.

Respondents were instructed to select only one of "Disease treatment", "Disease prevention" and "Growth promotion" as a primary reason for use of an antimicrobial.

ANTIMICROBIAL USE IN FEED—QUANTITATIVE METRICS

Figure 3. 18 Quantity of antimicrobials used in feed adjusted for population and broiler weight (mg/PCU) by province/region, 2013–2015



Province/region	British Columbia			Prairies			Ontario			Québec		
	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	24	29	25	15	37	38	30	42	49	28	33	23
Antimicrobial class												
I Macrolides	0	0	0	12	11	16	14	15	6	0	15	1
II Penicillins	25	10	9	0	0	0	0	2	13	0	11	3
III Streptogramins	17	13	11	18	7	6	35	9	7	20	4	1
IV Trimethoprim and sulfonamides	0	0	0	0	0	0	27	40	35	41	26	36
V Bacitracins	52	55	61	93	111	92	80	68	79	76	77	52
VI Tetracyclines	0	0	0	0	0	0	15	2	20	0	0	0
N/A Orthosomycins	0	4	7	0	1	6	0	11	15	0	11	7
Subtotal	94	82	88	123	130	120	171	147	175	137	143	101
IV Flavophospholipids	0	0	0	0	0	0	0	0	0	1	0	2
Ionophores	129	54	95	200	205	214	186	212	208	166	162	158
N/A Chemical coccidiostats	113	124	71	3	6	6	21	29	26	65	44	56
Subtotal (not in figure)	243	178	166	203	211	220	207	241	234	232	207	216
Total	337	260	254	326	341	340	378	388	409	369	350	317

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

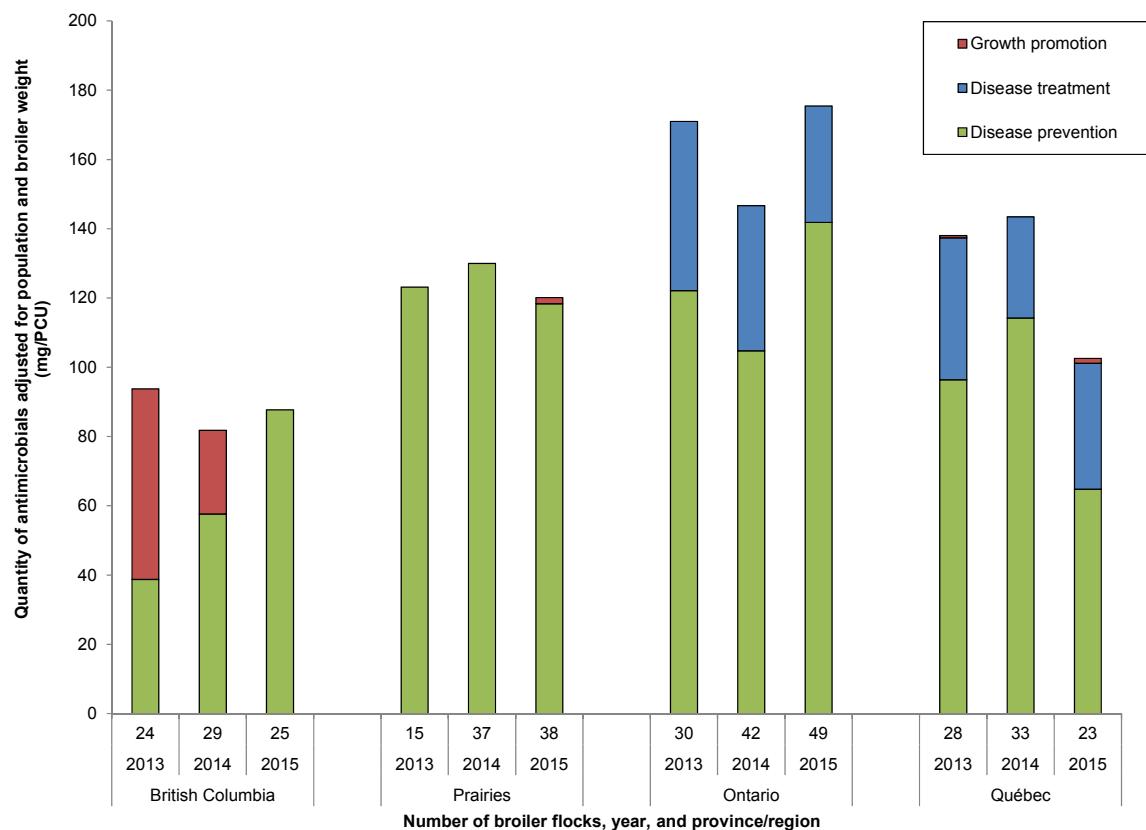
mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 19 Quantity of antimicrobials used in feed adjusted for population and broiler weight (mg/PCU), by primary reason for use and province/region, 2013–2015



Province/region Year Number of flocks	British Columbia			Prairies			Ontario			Québec		
	2013 24	2014 29	2015 25	2013 15	2014 37	2015 38	2013 30	2014 42	2015 49	2013 28	2014 33	2015 23
Reasons for use												
Disease prevention	39	58	88	123	130	118	122	105	142	96	114	65
Disease treatment	0	0	0	0	0	0	49	42	34	41	29	36
Growth promotion	55	24	0	0	0	2	0	0	0	1	0	1
Total	94	82	88	123	130	120	171	147	175	138	143	103

Ionophores and chemical coccidiostats that are mainly indicated for the prevention/treatment of coccidiosis were excluded in the above estimates.

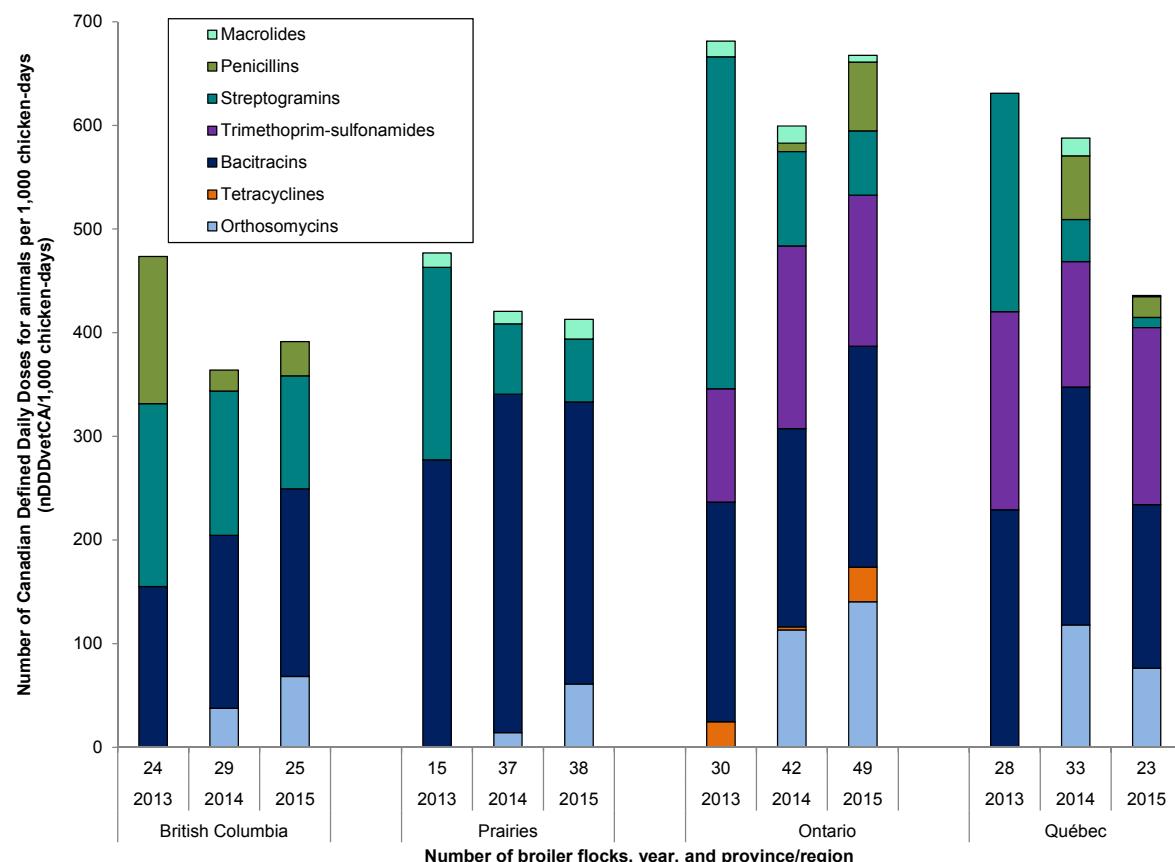
mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks \times 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 20 Number of Canadian Defined Daily Doses for animals per 1,000 chicken-days (nDDDvetCA/1,000 chicken-days) for antimicrobials administered in feed, by province/region, 2013–2015



Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

nDDDvetCA/1,000 chicken-days = Number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials in feed adjusted for DDDvetCA) divided by 1,000 chicken-days (adjusted for population and days in the grow-out period).

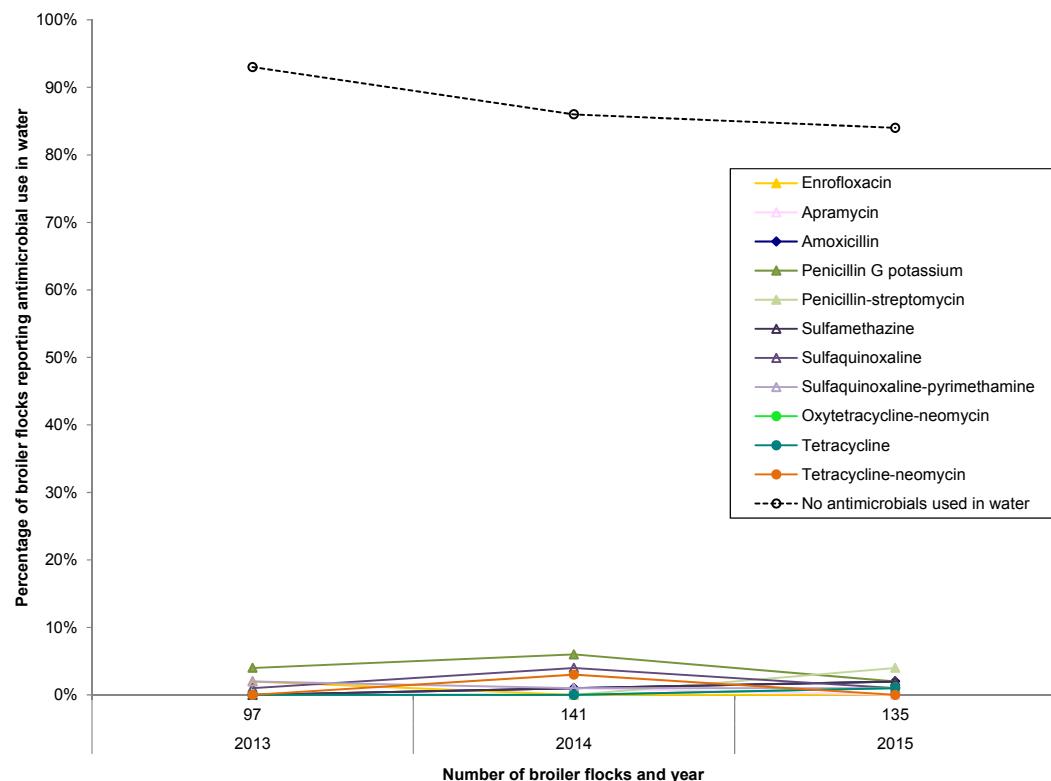
DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

The Prairies is a region including the provinces of Alberta and Saskatchewan.

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ANTIMICROBIAL USE IN WATER—FREQUENCY AND PRIMARY REASONS FOR USE

Figure 3. 21 Percentage of broiler flocks reporting antimicrobial use in water, 2013–2015



Year	2013	2014	2015
Number of flocks	97	141	135
Antimicrobial			
I Enrofloxacin	2%	0%	0%
Apramycin	0%	1%	0%
II Amoxicillin	0%	1%	2%
Penicillin G potassium	4%	6%	2%
Penicillin-streptomycin	0%	0%	4%
III Sulfamethazine	0%	1%	2%
Sulfaquinoxaline	1%	4%	1%
Sulfaquinoxaline-pyrimethamine	2%	1%	1%
Oxytetracycline-neomycin	0%	0%	1%
Tetracycline	0%	0%	1%
Tetracycline-neomycin	0%	3%	0%
No antimicrobials used in water	93%	86%	84%

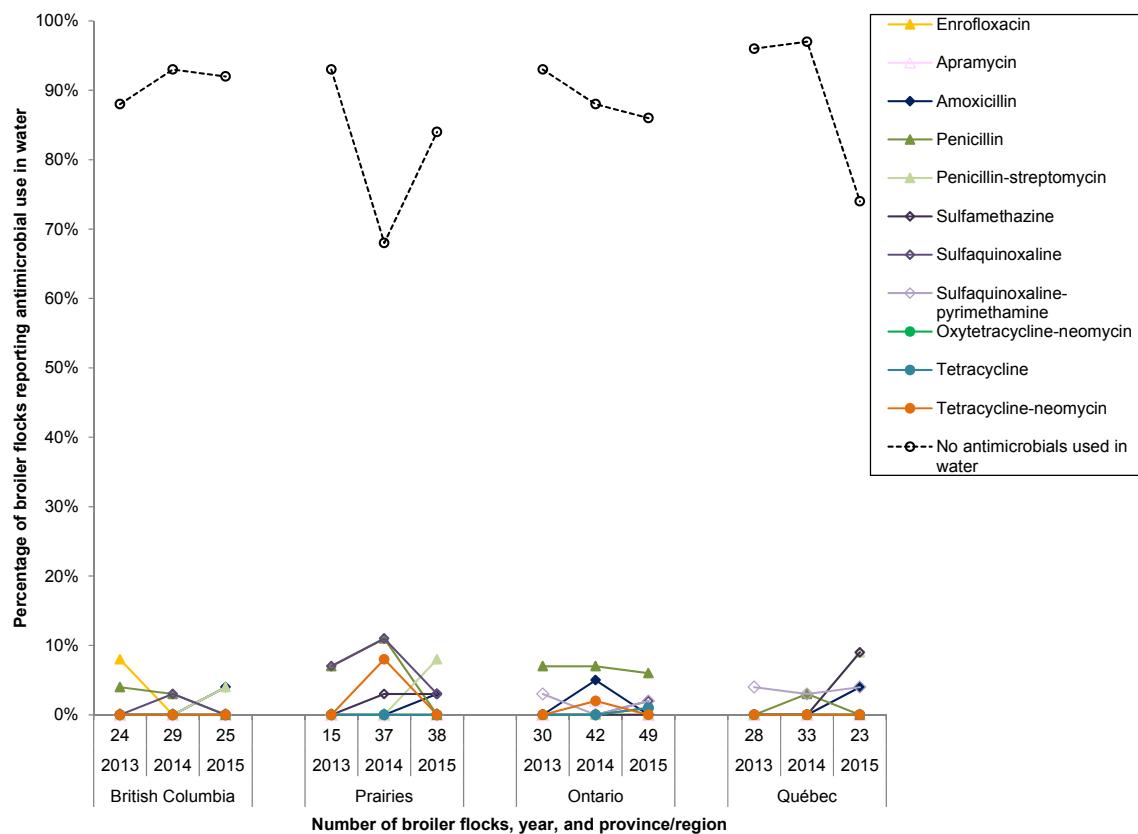
Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Numbers per column may not add up to 100% as some flocks have used an antimicrobial more than once or used multiple antimicrobials throughout the growing period.

For the temporal analysis, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences ($P \leq 0.05$) for a given antimicrobial.

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Figure 3. 22 Percentage of broiler flocks reporting antimicrobial use in water by province/region, 2013–2015



Province/Region	Year	British Columbia			Prairies			Ontario			Québec		
Number of flocks		2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Antimicrobial													
I	Enrofloxacin	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Apramycin	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%
II	Amoxicillin	0%	0%	4%	0%	0%	3%	0%	5%	0%	0%	0%	4%
Penicillin G potassium	4%	3%	0%	7%	11%	0%	7%	7%	6%	0%	3%	0%	0%
Penicillin-streptomycin	0%	0%	4%	0%	0%	8%	0%	0%	0%	0%	0%	0%	9%
Sulfamethazine	0%	0%	0%	0%	3%	3%	0%	0%	0%	0%	0%	0%	0%
Sulfaquinoxaline	0%	3%	0%	7%	11%	3%	0%	0%	2%	0%	0%	0%	0%
Sulfaquinoxaline-pyrimethamine	0%	0%	0%	0%	0%	0%	0%	3%	0%	2%	4%	3%	4%
Oxytetracycline-neomycin	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
Tetracycline	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
Tetracycline-neomycin	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%
No antimicrobials used in water	2013	88%	93%	92%	93%	68%	84%	93%	88%	86%	96%	97%	74%

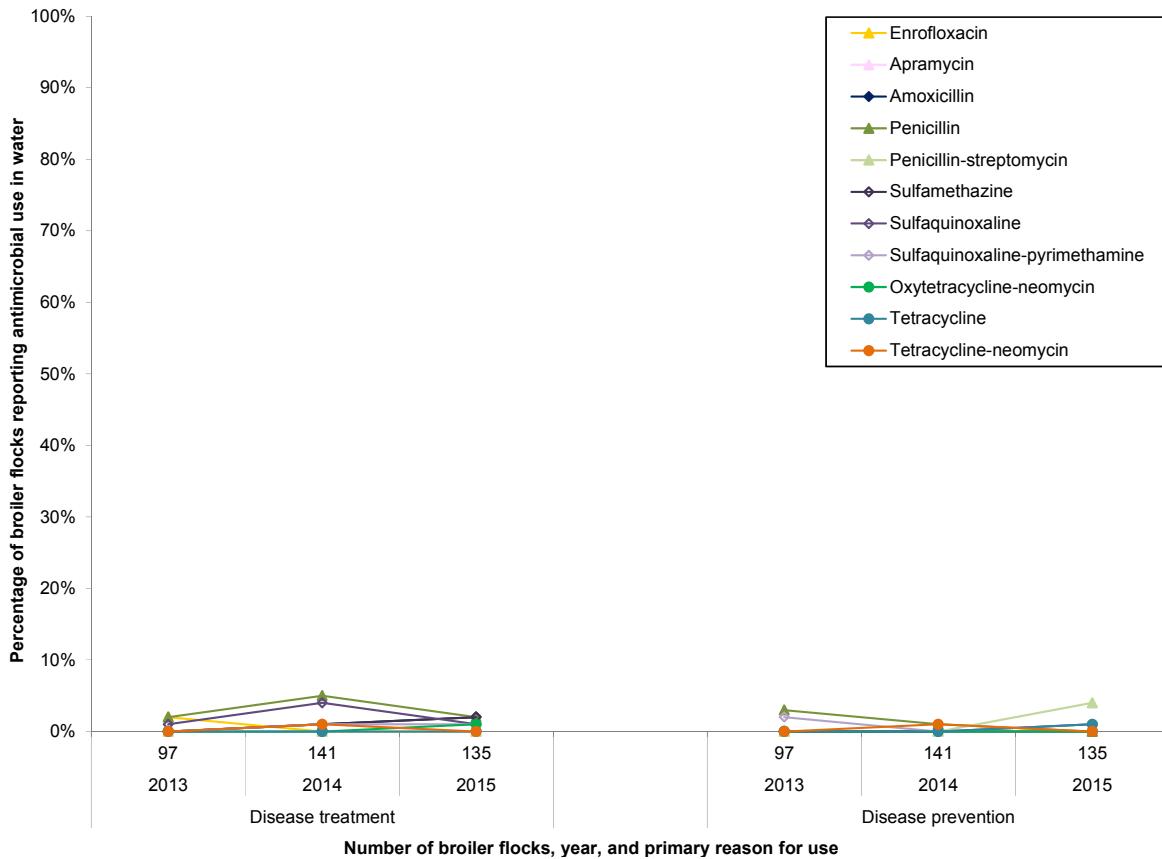
Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Numbers per column may not add up to 100% as some flocks have used an antimicrobial more than once or used multiple antimicrobials throughout the growing period.

For the temporal analyses within province/region, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 23 Percentage of flocks reporting antimicrobial use in water by primary reason for use, 2013–2015



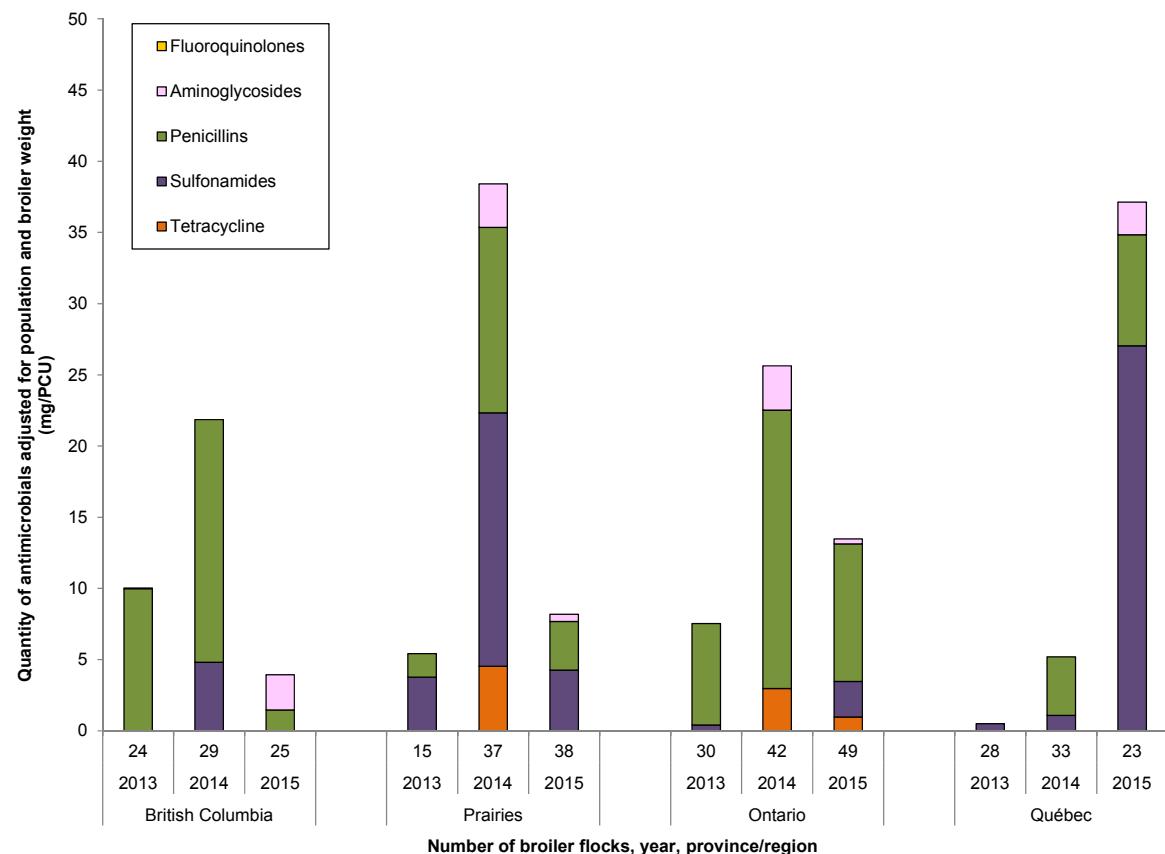
Primary reasons for use Year Number of flocks	Disease treatment			Disease prevention		
	2013 97	2014 141	2015 135	2013 97	2014 141	2015 135
Antimicrobial						
I Enrofloxacin	2%	0%	0%	0%	0%	0%
Apramycin	0%	1%	0%	0%	0%	0%
II Amoxicillin	0%	1%	2%	0%	0%	0%
Penicillin	2%	5%	2%	3%	1%	0%
Penicillin-streptomycin	0%	0%	0%	0%	0%	4%
Sulfamethazine	0%	1%	2%	0%	0%	0%
Sulfaquinoxaline	1%	4%	1%	0%	0%	1%
Sulfaquinoxaline-pyrimethamine	0%	1%	1%	2%	0%	0%
Oxytetracycline-neomycin	0%	0%	1%	0%	0%	0%
Tetracycline	0%	0%	0%	0%	0%	1%
Tetracycline-neomycin	0%	1%	0%	0%	1%	0%

Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Respondents were instructed to select only one of "Disease treatment" or "Disease prevention" as a primary reason for use of an antimicrobial.

ANTIMICROBIAL USE IN WATER—QUANTITATIVE METRICS

Figure 3. 24 Quantity of antimicrobials used in water adjusted for population and broiler weight (mg/PCU) by province/region, 2013–2015



Province/region	British Columbia			Prairies			Ontario			Québec		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks												
Antimicrobial class												
I Fluoroquinolones	< 0.1	0	0	0	0	0	0	0	0	0	0	0
II Aminoglycosides	0	0	2	0	3	1	0	3	0.4	0	0	2
Penicillins	10	17	1	2	13	3	7	20	10	0	4	8
III Sulfonamides	0	5	0	4	18	4	0.4	0	2	1	1	27
Tetracyclines	0	0	0	0	5	0	0	3	1	0	0	0
Subtotal	10	22	4	5	38	8	8	26	13	1	5	37
N/A Diaminopyrimidines	0	0	0	0	0	0	1	0	2	2	3	2
Subtotal (not in figure)	0	0	0	0	0	0	1	0	2	2	3	2
Total	10	22	4	5	38	8	9	26	15	2	8	39

Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

Antiprotozoals used in water (e.g., pyrimethamine, a diaminopyrimidine) were excluded in the estimates above.

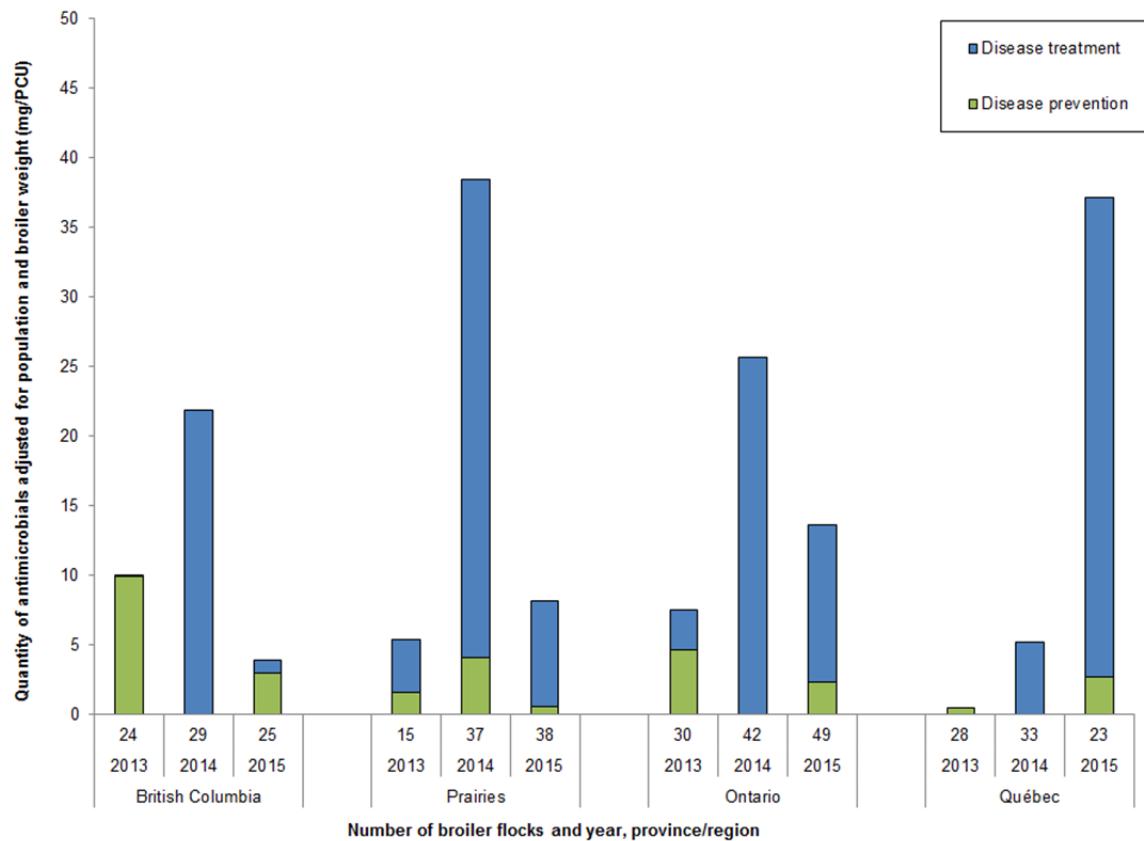
mg/PCU = mg (total milligrams of active ingredient consumed in water by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 25 Quantity of antimicrobials used in water adjusted for population and broiler weight (mg/PCU) by reasons for use and province/region, 2013–2015



Province/region	British Columbia			Prairies			Ontario			Québec		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	24	29	25	15	37	38	30	42	49	28	33	23
Reasons for use												
Disease prevention	10	0	3	2	4	1	5	0	2	1	0	3
Disease treatment	< 1	22	1	4	34	8	3	26	11	0	5	34
Total	10	22	4	5	38	8	8	26	13	1	5	37

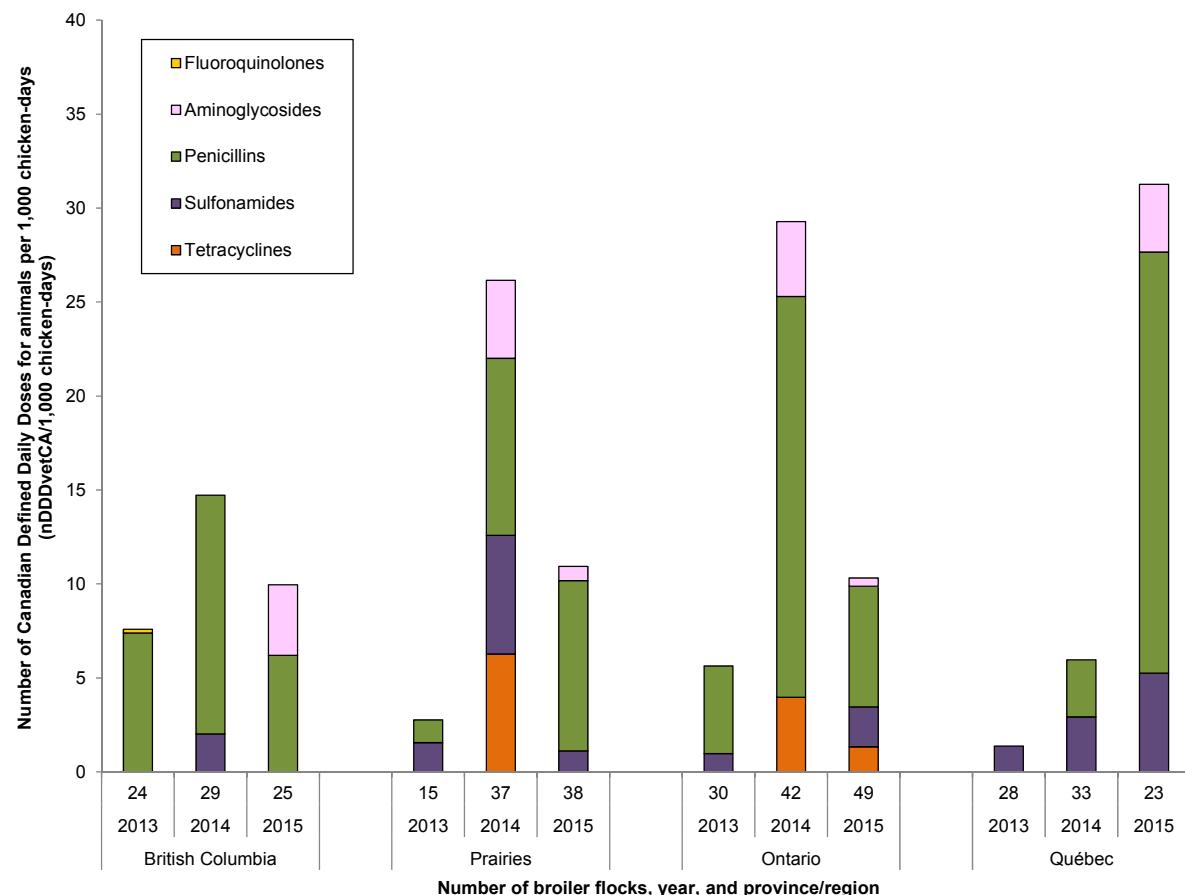
mg/PCU = mg (total milligrams of active ingredient consumed in water by participating flocks) divided by PCU.

PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 26 Number of Canadian Defined Daily Doses for animals per 1,000 chicken-days (nDDDvetCA/1,000 chicken-days) for antimicrobials administered in water, by province/region, 2013–2015



Province/region Year Number of flocks	British Columbia			Prairies			Ontario			Québec		
	2013 24	2014 29	2015 25	2013 15	2014 37	2015 38	2013 30	2014 42	2015 49	2013 28	2014 33	2015 23
Antimicrobial class												
I Fluoroquinolones	0.2	0	0	0	0	0	0	0	0	0	0	0
II Aminoglycosides	0	0	4	0	4	1	0	4	0	0	0	4
III Penicillins	7	13	6	1	9	9	5	21	6	0	3	22
Sulfonamides	0	2	0	2	6	1	1	0	2	1	3	5
Tetracyclines	0	0	0	0	6	0	0	4	1	0	0	0
Subtotal	8	15	10	3	26	11	6	29	10	1	6	31
N/A Diaminopyrimidines	0	0	0	0	0	0	10	0	14	14	29	18
Subtotal (not in figure)	0	0	0	0	0	0	10	0	14	14	29	18
Total	8	15	10	3	26	11	15	29	24	15	35	49

Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing this report).

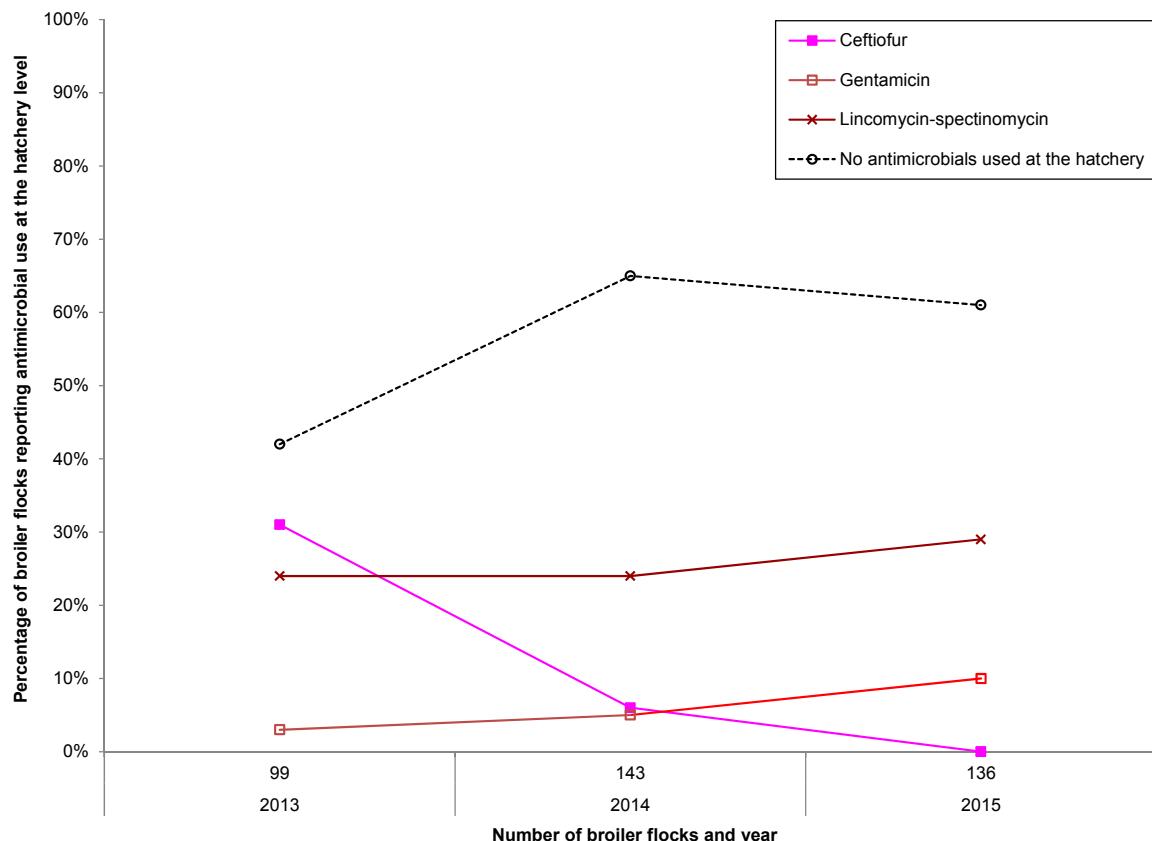
nDDDvetCA/1,000 chicken-days = number of Defined Daily Doses for animals (pertains to the quantity of antimicrobials in water adjusted for DDDvetCA) divided by 1,000 chicken-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

The Prairies is a region including the provinces of Alberta and Saskatchewan.

ANTIMICROBIAL USE *IN OVO* OR VIA SUBCUTANEOUS INJECTION— FREQUENCY AND PRIMARY REASONS FOR USE

Figure 3. 27 Percentage of broiler flocks reporting antimicrobial use *in ovo* or via subcutaneous injection at the hatchery level, 2013–2015



Year	2013	2014	2015
Number of flocks	99	143	136
Antimicrobial			
I Ceftiofur	31%	6%	0%
II Gentamicin	3%	5%	10%
Lincomycin-spectinomycin	24%	24%	29%
No antimicrobials used at the hatchery	42%	65%	61%

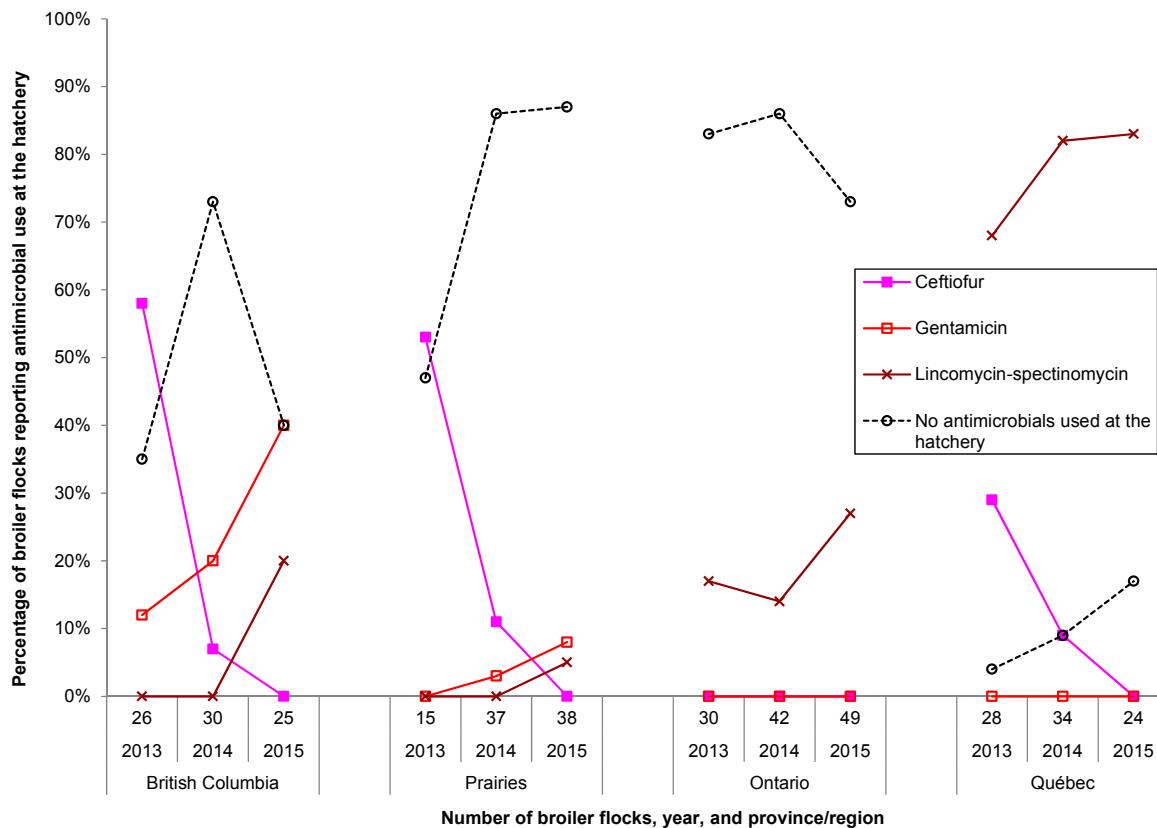
Roman numerals I to II indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Numbers per column may not add up to 100% due to rounding or batches of chicks (hatched at the same time to supply one barn) may have used more than one antimicrobial.

Data represent flocks medicated at the hatchery at day 18 of incubation or upon hatch.

For the temporal analyses, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences ($P \leq 0.05$) for a given antimicrobial.

Figure 3. 28 Percentage of broiler flocks reporting antimicrobial use *in ovo* or via subcutaneous injection at the hatchery level by province/region, 2013–2015



Province/region		British Columbia			Prairies			Ontario			Québec		
Year	Number of flocks	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Antimicrobial													
I Ceftiofur	58%	7%	0%	53%	11%	0%	0%	0%	0%	29%	9%	0%	
II Gentamicin	12%	20%	40%	0%	3%	8%	0%	0%	0%	0%	0%	0%	
Lincomycin-spectinomycin	0%	0%	20%	0%	0%	5%	17%	14%	27%	68%	82%	83%	
No antimicrobials used at the hatchery	35%	73%	40%	47%	86%	87%	83%	86%	73%	4%	9%	17%	

Roman numerals I to II indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

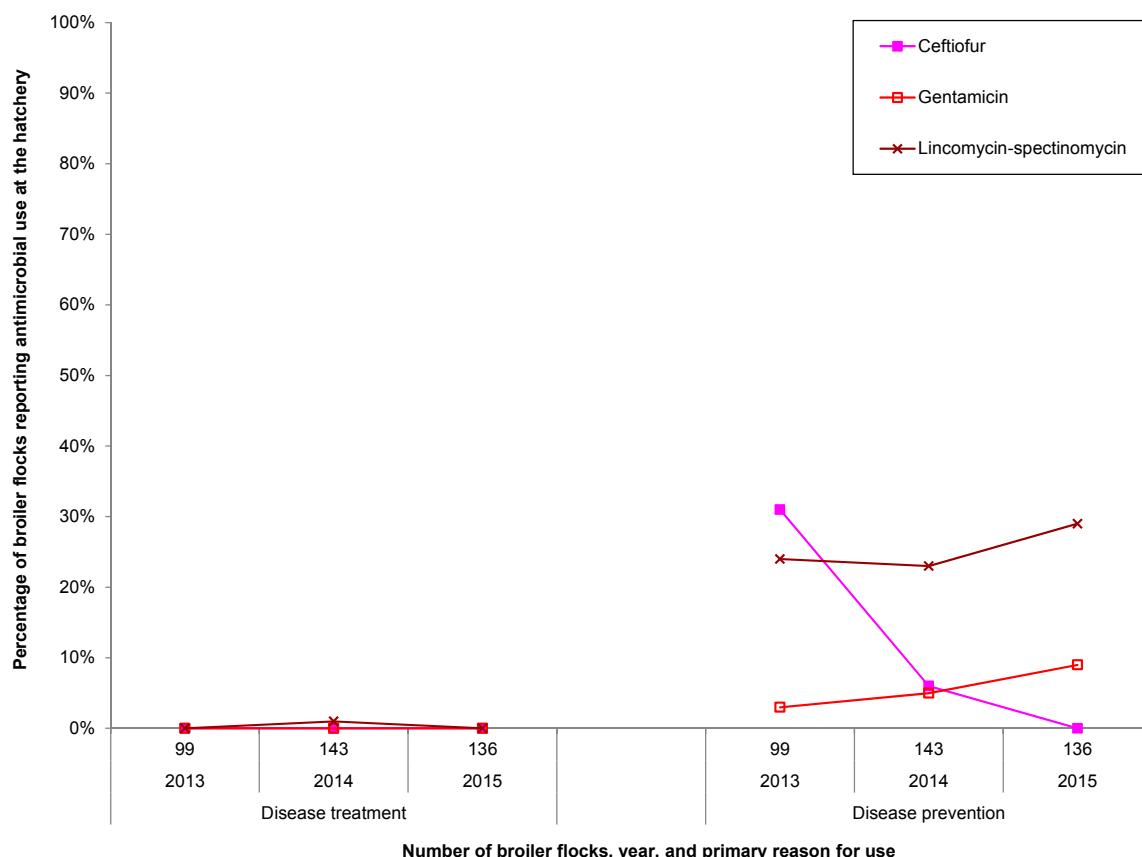
Numbers per column may not add up to 100% due to rounding or batches of chicks (hatched at the same time to supply one barn) may have used more than one antimicrobial.

Data represent flocks medicated at the hatchery at day 18 of incubation or upon hatch.

For the temporal analyses within province/region, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2013 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 3. 29 Percentage of flocks reporting antimicrobial use *in ovo* or via subcutaneous injection at the hatchery by primary reason for use, 2013–2015



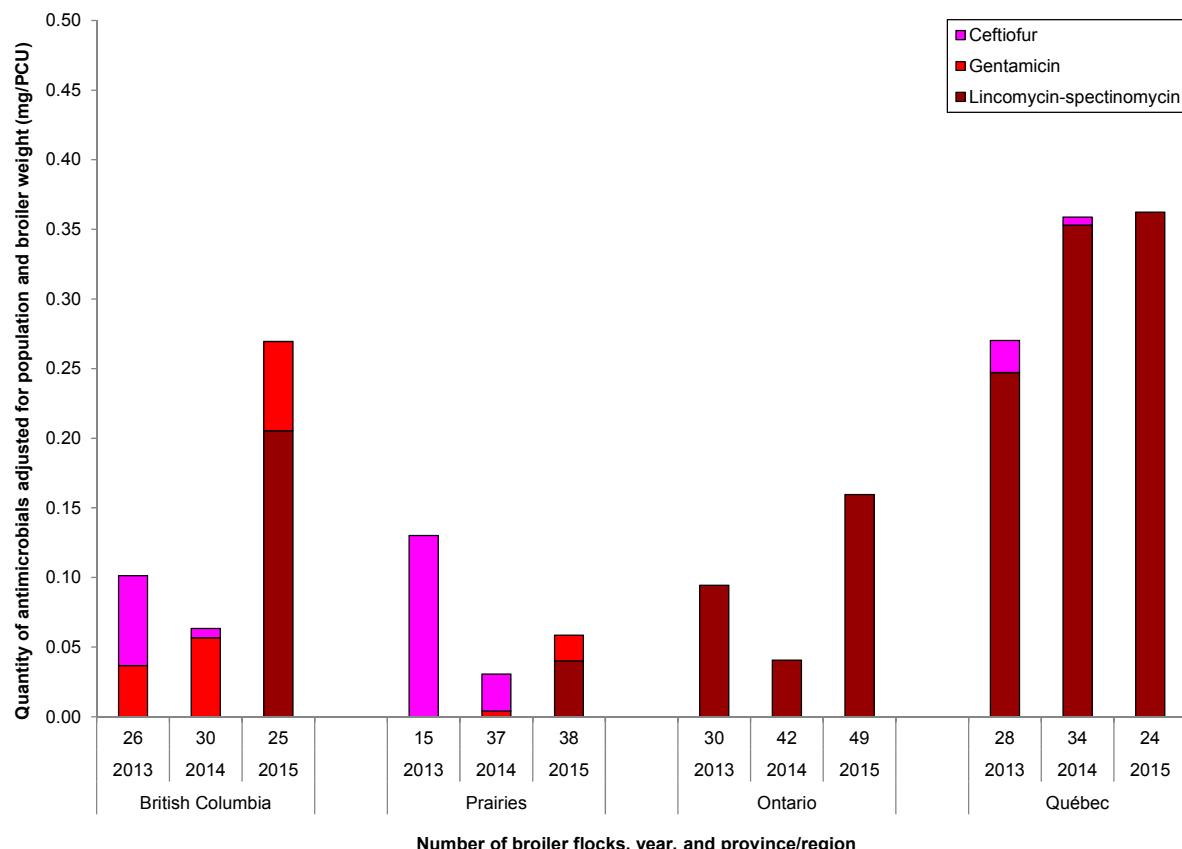
Primary reasons for use Year Number of flocks	Disease treatment			Disease prevention		
	2013 99	2014 143	2015 136	2013 99	2014 143	2015 136
Antimicrobial						
I Ceftiofur	0%	0%	0%	31%	6%	0%
II Gentamicin	0%	0%	0%	3%	5%	9%
Lincomycin-spectinomycin	0%	1%	0%	24%	23%	29%

Roman numerals I to II indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Respondents were instructed to select only one of "Disease treatment", "Disease prevention", "High risk breeder flock source" (i.e., hatching eggs from old flocks that may have poor shell quality; any disease pressure, infectious or metabolic) and "Producer request" as a primary reason for use of an antimicrobial. The last 3 primary reasons were combined in the table above.

ANTIMICROBIAL USE *IN OVO* OR VIA SUBCUTANEOUS INJECTION— QUANTITATIVE METRICS

Figure 3. 30 Quantity of antimicrobials used *in ovo* or via subcutaneous injection, adjusted for population and broiler weight (mg/PCU), by province/region, 2013–2015



Province/region	British Columbia			Prairies			Ontario			Québec		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	26	30	25	15	37	38	30	42	49	28	34	24
Antimicrobials												
I Ceftiofur	0.06	0.01	0.00	0.13	0.03	0.00	0.00	0.00	0.00	0.02	0.01	0.00
II Gentamicin	0.04	0.06	0.06	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Lincomycin-spectinomycin	0.00	0.00	0.21	0.00	0.00	0.04	0.09	0.04	0.15	0.25	0.35	0.36
Total	0.10	0.06	0.27	0.13	0.03	0.06	0.09	0.04	0.15	0.27	0.36	0.36

Roman numerals I to II indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Total milligrams active ingredient was calculated using the final dose (in mg per hatching egg or chick) suggested by the manufacturer and expert opinion based on milligrams per body weight or residue avoidance information: ceftiofur routine dose (0.10 to 0.20 mg/egg or chick), gentamicin routine dose (0.20 mg/chick or egg), lincomycin-spectinomycin routine dose (0.75 mg/egg or chick consisting of 0.50 mg spectinomycin and 0.25 mg of lincomycin).

mg/PCU = mg (total milligrams of active ingredient administered to participating herds by injection) divided by PCU.

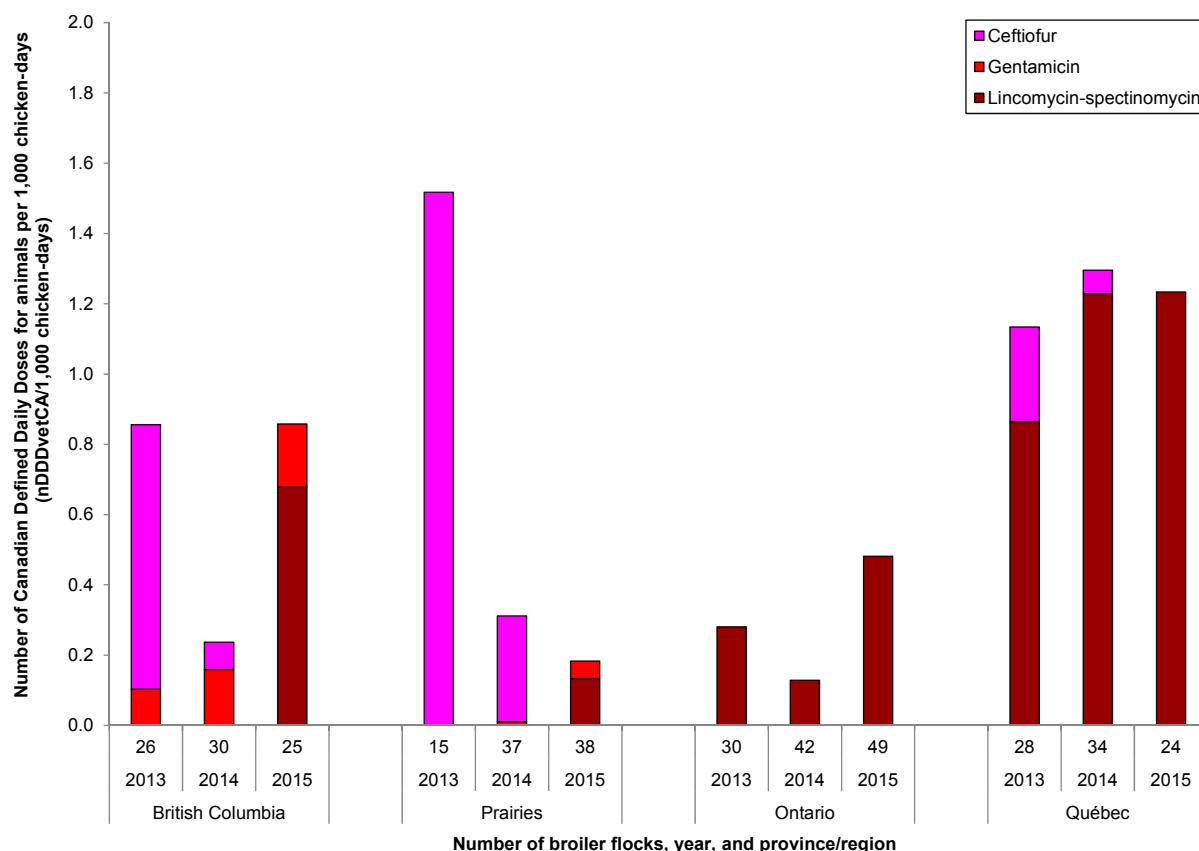
PCU = population correction unit; total number of birds in the sampled broiler flocks x 1 kg/bird (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

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

**Figure 3. 31 Number of Canadian Defined Daily Doses for animals per 1,000 chicken-days
(nDDDvetCA/1,000 chicken-days) for antimicrobials administered *in ovo* or via
subcutaneous injection, by province/region, 2013–2015**



Province/region	British Columbia			Prairies			Ontario			Québec		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Number of flocks	24	29	25	15	37	38	30	42	49	28	33	24
Antimicrobials												
I Ceftiofur	0.8	0.1	0	1.5	0.3	0	0	0	0	0.3	0.1	0
II Gentamicin	0.1	0.2	0.2	0	< 0.1	< 0.1	0	0	0	0	0	0
Lincomycin-spectinomycin	0	0	0.7	0	0	0.1	0.3	0.1	0.5	0.9	1.2	1.2
Total	0.9	0.2	0.9	1.5	0.3	0.2	0.3	0.1	0.5	1.1	1.3	1.2

Roman numerals I to II indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

nDDDvetCA/1,000 chicken-days = number of Defined Daily Doses for animals (pertains to the quantity of antimicrobials administered via injection adjusted for DDDvetCA) divided by 1,000 chicken-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

The Prairies is a region including the provinces of Alberta and Saskatchewan.

FARM SURVEILLANCE—GROWER-FINISHER PIGS

KEY FINDINGS

There were 85 grower-finisher pig herds participated in *Farm Surveillance* in 2015. Most of the participating herds reported using antimicrobials in feed (65 herds, 76%) and by injection (43 herds, 51%). Seventeen herds (20%) reported using antimicrobials in water and 9 herds (10%) reported no use of antimicrobials by any route of administration. The most frequently reported antimicrobials used were penicillin G (37 herds, 44%) mostly by injection, lincomycin (33 herds, 39%), and tylosin (23 herds, 27%) mainly in feed, and chlortetracycline (30 herds, 35%) all in feed.

In 2015, the percentage of non-medicated rations was 35% (142/400). The percentage of rations medicated with Category II-III antimicrobials was 45% (178/400) and that for Category IV was 20% (80/400), for a total proportion medicated of 65% (258/400). The percentage of non-medicated rations was higher in 2015 compared to 2009 (31%, 123/397) and 2014 (33%, 151/455). The percentage of rations medicated with Cat. II-III antimicrobials are trending downward from 2009 at 58% (230/397) and 2014 at 52% (237/455), while the number of rations medicated with Category IV antimicrobials have increased from 11% (44/397) in 2009 and 15% (67/455) in 2014.

In 2015, the median days exposed was 28 days for non-medicated rations and those medicated with Category IV antimicrobials; for rations medicated with Category II or III antimicrobials, pigs were exposed for a median of 21 days, up from 17.5 days in 2014.

At a national level, a significant decrease in tylosin use in feed was noted between 2009 (41%, 39/95 herds) and 2015 (25%, 21/85 herds) (Figure 3. 32), which appeared to be due to a regional decrease in tylosin use in the Prairies and Ontario (Figure 3. 33). Tylvalosin, sulfamethazine, and bambermycin use in feed appeared to be on the increase, due largely to an increased use in Ontario and Québec herds; however, this increase was not statistically significant.

Most of the feed antimicrobial use reported in Québec was for growth promotion and disease prevention purposes, but in Ontario most feed use was only for disease prevention purposes. Disease treatment was the least frequently cited reason for antimicrobial use in feed across all regions (Figure 3. 34).

In 2015, 12% of herds reported using florfenicol by injection; this was a significant increase since 2009 when just 1% of herds reported using florfenicol (Figure 3. 44).

Disease pressures on grower-finisher farms were significantly different between regions. This data can be viewed in Chapter 2—Animal Health Status and Farm Information. Overall, herd size was larger, farm density lower and source of pigs was different on the Prairies compared to Ontario and Québec. These are all factors which could affect regional frequencies of AMU.

ADMINISTRATION IN FEED

HERD USE FREQUENCY—OVER ALL HERDS (FIGURE 3. 32)

The use of tylosin in feed has decreased significantly in 2015 (25%, 21/85) since 2009 (41%, 39/95); otherwise there were no significant changes in the number of herds reporting the use of specified antimicrobials in feed in 2015. In both 2014 and 2015, the emerging use of tylvalosin, and re-emerging use sulfamethazine and bambermycin in feed were noted.

In 2015, there was no significant change overall in the number of herds reporting no antimicrobials use in feed.

HERD USE FREQUENCY—BY PROVINCE/REGION (FIGURE 3. 33)

There was a notable increase in lincomycin use in Ontario comparing 2011 to 2015, while the uses of tiamulin and sulfamethazine were more prevalent in the Prairies. The use of chlortetracycline in feed was significantly higher in Québec compared to the Prairies in 2015. Québec herds reported the use of tilmicosin and bambermycin; there was no reported use of these antimicrobials in feed by herds in the Prairies and Ontario.

HERD USE FREQUENCY—PRIMARY REASONS FOR USE BY PROVINCE/REGION

In the Prairies, the proportion of herds reporting antimicrobial use for growth promotion decreased from 49% (18/37) in 2011 to 23% (9/39) in 2015 (Figure 3. 34).

In 2015, the proportion of herds reporting the use of antimicrobials in feed for growth promotion was greater in Québec 67% (14/21) compared to Ontario 24% (6/25) and the Prairie 23% (9/39) region (Figure 3. 34).

In 2015, the proportion of herds indicating that the primary reason for using tetracyclines (25%, 21/85), lincosamides (21%, 18/85) and macrolides (19%, 16/85) in feed was for disease prevention remained stable compared to previous years (Figure 3. 35).

The proportion of herds reporting the use of macrolides in feed for growth promotion decreased to 12% (10/85) in 2015 from 23% (22/95) in 2009, while the proportion of herds reporting growth promotion uses of ionophores increased from 13% (12/95) to 18% (15/85) over the same period (Figure 3. 35).

RATION FREQUENCY—DURATION OF EXPOSURE (FIGURE 3. 36)

In 2015, a large proportion of rations medicated with salinomycin, tylosin and lincomycin were fed throughout the grow-finish period (30-120 kg body weight [BW]). The proportion of rations medicated with chlortetracycline and penicillin diminished from a 100% of rations in the early grower phase (30-49 kg BW) to less than 10% by the mid to late grow-finish period (60-89 kg BW).

QUANTITY OF ANTIMICROBIAL USE ADJUSTED FOR POPULATION AND PIG WEIGHT (MG/PCU)

Over all provinces/regions, the total quantity of antimicrobial use in feed increased from 165 mg/PCU in 2014 to 176 mg/PCU in 2015 (Figure 3. 37). There was a decreasing trend in Québec in the total quantity of antimicrobial use in feed (excluding ionophores and flavophospholipids), from 272 mg/PCU in 2011 to 211 mg/PCU in 2015 (Figure 3. 37). In Ontario the trend has been increasing since 2011 going from 81 mg/PCU to 197 mg/PCU in 2015 (Figure 3. 37), while in the Prairies there was less variation in the total quantity of antimicrobial use in feed over this period ending with a total of 156 mg/PCU in 2015.

Excluding ionophores and flavophospholipids, 89% (156/176 mg/PCU) of the total quantity of antimicrobial use in feed was made up largely of tetracyclines (55%, 97/176 mg/PCU), lincosamides (18%, 32/176 mg/PCU) and macrolides (15%, 27/176 mg/PCU) (Figure 3. 38).

In addition to the rising quantity of tetracycline use, the increase in the total quantity of use in feed overall antimicrobials is due, in part, to an increase in the quantity of streptogramin use (virginiamycin): 1.3 mg/PCU in 2011 up to 9 mg/PCU in 2015.

QUANTITY OF ANTIMICROBIAL USE (MG/PCU)—BY PROVINCE/REGION (FIGURE 3. 39)

Regional trends in the quantity of antimicrobial use in feed (mg/PCU) indicated that the reduction noted in Québec (2011–2014) was due largely to a decrease in the use of tetracyclines. However, over all 5 years depicted, the quantity of tetracycline use reported in Québec was generally higher relative to the other regions. In Ontario, the overall increase appeared to be related to an increase in the quantity of tetracycline, streptogramin and pleuromutilin use. Quantity of antimicrobial use in feed reported in the Prairies was relatively stable and trending downward in 2015, noting less use of pleuromutilins (tiamulin).

NUMBER OF CANADIAN DEFINED DAILY DOSES FOR ANIMALS OF ANTIMICROBIALS ADJUSTED FOR PIG POPULATION AND THE TIME IN THE GROW-FINISH PERIOD (NDDDvetCA/1,000 PIG-DAYS) (FIGURE 3. 40)

Over all provinces/regions, the total quantity of Category II and III antimicrobial use in feed was 275 nDDDvetCA/1,000 pig-days in 2015, which was similar to the 2 previous years. This flat trend in the total quantity of Category II and III antimicrobial use in feed, expressed as nDDDvetCA/1,000 pig-days, was not consistent with the increasing trend noted on a mg/PCU basis (Figure 3. 38).

Excluding ionophores and flavophospholipids, 80% (218/275 nDDDvetCA/1,000 pig-days) of the total quantity of antimicrobial use in feed was made up largely of tetracyclines (30%, 82/275 nDDDvetCA/1,000 pig-days), macrolides (28%, 76/275 nDDDvetCA/1,000 pig-days) and lincosamides (22%, 60/275 nDDDvetCA/1,000 pig-days) in 2015. There was an increase in the quantity of streptogramin use in 2015 (24 nDDDvetCA/1000 pig-days) compared to 2014 (4 nDDDvetCA/1,000 pig-days).

NUMBER OF DEFINED DAILY DOSES FOR ANIMALS OF ANTIMICROBIAL USE
ADJUSTED FOR PIG POPULATION AND THE TIME IN THE GROW-FINISH PERIOD
(NDDDvetCA/1,000 PIG-DAYS)—BY PROVINCE/REGION (FIGURE 3. 41).

Provincial/regional trends were similar between the 2 use metrics, mg/PCU and nDDDvetCA/1,000 pig-days in 2015. Provincial/regional trends in the quantity of antimicrobial use in feed (nDDDvetCA/1,000 pig-days) also indicated that the overall (Category II and III) reduction noted in Québec was due largely to a decrease in the use of tetracyclines, 177 in 2011 to 137 nDDDvetCA/1,000 pig-days in 2015.

Over all 5 years depicted, the quantity of tetracycline use reported in Québec remained generally higher relative to the other regions. In Ontario, the overall increase appeared to be related to an increase in the quantity of tetracycline, streptogramin and pleuromutilin use in the face of decreasing quantities of lincosamides, macrolide and penicillin use. The quantity of antimicrobial use in feed reported in the Prairies was relatively stable and again, was trending downward in 2015, noting less use of pleuromutilins (tiamulin).

ADMINISTRATION IN WATER

Penicillin continues to be the antimicrobial used in water by the greatest proportion of herds, ranging from 21% (19/95) in 2009 to 12% (10/85) of herds in 2015 (Figure 3. 42). The proportion of Prairie herds reporting that they did not use antimicrobials in water in grower-finisher pig herds was significantly higher (88%, 38/43) compared to that reported by Québec herds (42%, 11/26) (Figure 3. 43). Additionally, lincomycin use in water was only reported by Québec herds (Figure 3. 43).

ADMINISTRATION BY INJECTION

Over the period 2009-2015, the antimicrobial reported by the greatest proportion of herds for use by injection was penicillin (Figure 3. 44). The proportion of herds reporting the use of florfenicol by injection increased significantly from 1% (1/95) in 2009 to 12% (10/85) in 2015 (Figure 3. 44).

In Québec the proportion of herds reporting penicillin use by injection decreased significantly in 2015 (33%, 7/21) compared to that in 2011 (68%, 19/28) (Figure 3. 45). In the Prairies, the proportion of pig herds reporting the use of florfenicol by injection (3%, 1/39) was significantly lower than that in Québec (24%, 5/21) (Figure 3. 45). In 2015, a significantly higher number of Ontario pig herds (48%, 12/25) reported using penicillin by injection compared to that by Prairie pig herds (23%, 9/39) (Figure 3. 45). Similarly, the proportion of Ontario pig herds reporting the use of oxytetracycline use by injection (24%, 6/25) was significantly higher than that reported by Prairie herds (3%, 1/39); no Québec herds reported this antimicrobial use in 2015 (Figure 3. 45).

SUMMARY OF ANTIMICROBIAL USE—ALL ROUTES OF ADMINISTRATION

Table 3. 9 Number of grower-finisher pig herds with reported antimicrobial use by route of administration, 2015

Antimicrobial use	Route of administration			
	Any route ^a n (%)	Feed n (%)	Water n (%)	Injection n (%)
Any antimicrobial use	75 (88)	65 (76)	17 (20)	43 (51)
No antimicrobial use	10 (12)	20 (24)	68 (80)	42 (49)
Total herds	85 (100)	85 (100)	85 (100)	85 (100)

^a Herds with reported use of an antimicrobial class by feed, water, injection, or any combination of these routes are included in each count.

Table 3. 10 Number of grower-finisher pig herds with reported use of specific active antimicrobial ingredients by route of administration, 2015

Antimicrobial class	Antimicrobial	Route of administration			
		Any route ^a n (%)	Feed n (%)	Water n (%)	Injection n (%)
I Extended-spectrum cephalosporins	Ceftiofur	17 (20)	0 (0)	0 (0)	17 (20)
Aminoglycosides	Streptomycin	5 (6)	0 (0)	5 (6)	0 (0)
Lincosamides	Lincomycin	33 (39)	26 (31)	3 (4)	7 (8)
Macrolides	Erythromycin	0 (0)	0 (0)	0 (0)	0 (0)
	Tilmicosin	3 (4)	3 (4)	0 (0)	0 (0)
	Tulathromycin	6 (7)	0 (0)	0 (0)	6 (7)
II	Tylosin	23 (27)	21 (25)	0 (0)	2 (2)
	Tylvalosin	4 (5)	4 (5)	0 (0)	0 (0)
Penicillins	Ampicillin	4 (5)	0 (0)	0 (0)	4 (5)
	Penicillin G	37 (44)	7 (8)	10 (12)	28 (33)
Combination of sulfadoxine and trimethoprim	Trimethoprim-sulfadoxine	9 (11)	0 (0)	3 (4)	8 (9)
Streptogramins	Virginiamycin	1 (1)	1 (1)	0 (0)	0 (0)
Aminocyclitols	Spectinomycin	1 (1)	1 (1)	0 (0)	0 (0)
Aminoglycosides	Neomycin	2 (2)	0 (0)	2 (2)	0 (0)
Bacitracins	Bacitracin	0 (0)	0 (0)	0 (0)	0 (0)
Phenicols	Florfenicol	10 (12)	0 (0)	0 (0)	10 (12)
III Pleuromutilins ^b	Tiamulin	5 (6)	5 (6)	0 (0)	0 (0)
	Sulfonamides	6 (7)	5 (6)	1 (1)	0 (0)
Tetracyclines	Chlortetracycline	30 (35)	30 (35)	0 (0)	0 (0)
	Oxytetracycline	8 (9)	1 (1)	0 (0)	7 (8)
	Tetracycline	2 (2)	0 (0)	2 (2)	0 (0)
IV Flavophospholipids	Bambermycin	4 (5)	4 (5)	0 (0)	0 (0)
Ionophores	Salinomycin	19 (22)	19 (22)	0 (0)	0 (0)

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

^a Herds with reported use of an antimicrobial class by feed, water, injection, or any combination of these routes are included in each count.

^b Pleuromutilins are not officially categorized in the current Health Canada Classification System. However, according to the criteria provided by Health Canada, pleuromutilins meet the criteria for Category III.

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Table 3. 11 Frequency and quantity of antimicrobial use summary in feed, 2015

Antimicrobial	Herd n (%)	Ration n (%) <small>*Total n=400</small>	Ration days exposed ^a median (min. ; max.)	Percent of herd exposed median (min. ; max.)	Weight at exposure median ^b (min. ; max.) ^c	Level of drug g/tonne ^d median (min. ; max.)	Quantity of antimicrobial active ingredient ^e		
							mg/PCU ^f	Herd level nDDDvetCA / 1,000 pig-days ^g median (min. ; max.)	Ration level nDDDvetCA / 1,000 pig-days ^h
Lincomycin	26 (31)	59 (23)	21 (3 ; 70)	100 (15 ; 100)	70 (20 ; 125)	44 (22 ; 220)	31	126 (9 ; 764)	60
Penicillin	7 (8)	8 (3)	25 (6 ; 35)	100 (100 ; 100)	38 (23 ; 65)	88 (55 ; 132)	3	185 (83 ; 691)	13
II Tilmicosin	3 (4)	3 (1)	14 (7 ; 14)	100 (100 ; 100)	81 (68 ; 86)	200 (200 ; 200)	2	57 (29 ; 72)	2
Tylosin	21 (25)	50 (19)	28 (3 ; 63)	100 (5 ; 100)	71 (23 ; 145)	22 (11 ; 201)	24	48 (7 ; 232)	70
Tylvalosin	4 (5)	4 (2)	21 (7 ; 35)	100 (100 ; 100)	45 (25 ; 82)	43 (2 ; 43)	1	198 (2 ; 863)	5
Virginiamycin	1 (1)	4 (2)	28 (28 ; 28)	100 (100 ; 100)	75 (25 ; 125)	250 (250 ; 250)	9	2,524 (2,524 ; 2,524)	24
Chlortetracycline	30 (35)	36 (14)	18 (4 ; 42)	100 (50 ; 100)	36 (23 ; 94)	550 (110 ; 1,100)	97	180 (44 ; 973)	82
Oxytetracycline	1 (1)	1 (0)	14 (14 ; 14)	100 (100 ; 100)	73 (55 ; 90)	550 (550 ; 550)	0.4	335 (335 ; 335)	0
III Spectinomycin	1 (1)	2 (1)	21 (21 ; 21)	100 (100 ; 100)	41 (25 ; 60)	22 (22 ; 22)	0.5	290 (290 ; 290)	4
Sulfamethazine	5 (6)	5 (2)	21 (6 ; 35)	100 (100 ; 100)	39 (23 ; 57)	110 (55 ; 220)	3	104 (36 ; 190)	5
Tiamulin	5 (6)	6 (2)	18 (11 ; 35)	100 (100 ; 100)	56 (23 ; 90)	44 (18 ; 280)	5	57 (33 ; 454)	9
Subtotal Cat. II and III	59 (69)	178 (45)*	21 (3 ; 70)	100 (5 ; 100)	53 (20 ; 145)		N/A	176	N/A
Bambermycin	4 (5)	7 (3)	28 (14 ; 56)	100 (100 ; 100)	73 (37 ; 130)	2 (2 ; 20)	0.1	47,810 (12,019 ; 116,000)	926
IV Narasin	2 (2)	6 (2)	32 (14 ; 56)	100 (100 ; 100)	67 (30 ; 125)	15 (15 ; 15)	1		10
Salinomycin	19 (22)	67 (26)	28 (7 ; 56)	100 (50 ; 100)	75 (23 ; 130)	25 (25 ; 417)	89	770 (415 ; 14,286)	784
Subtotal Cat. IV	25 (29)	80 (20)*	28 (7 ; 56)	100 (50 ; 100)	75 (23 ; 130)		N/A	90	N/A
Total for feed	65 (76)	258 (65)*	28 (3 ; 182)	100 (50 ; 100)	62 (20 ; 145)		N/A	266	N/A
No AMU in feed	20 (24)	142 (35)*	28 (3 ; 70)	100 (5 ; 100)	82 (20 ; 154)		N/A	N/A	N/A

See corresponding footnotes on the next page.

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate. N/A = not applicable (no classification available at the time of writing of this report).

PCU = population correction unit; total number of pigs in the sampled grower-finisher herds x 65 kg/pig (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram pig ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).
nDDDvetCA are also available using European standards.

^a Ration days exposed = for rations medicated with the specific antimicrobial and do not reflect the full grow-out period.

^b Median weight at exposure = the median of all average weights of pigs exposed to a ration containing a specific antimicrobial [(Ration Start Weight + Ration End Weight)/2]

^c Minimum (min.) and maximum (max.) pig weight at exposure = the lowest start weight and the highest end weight reported for all rations containing the specific antimicrobial, respectively.

^d Level of drug is in grams/tonne of feed.

^e Quantitative antimicrobial consumption estimates were calculated using reported ration days fed and predicted feed intake²⁷, adjusted for herd average daily gain; only rations medicated with the specific antimicrobial were included in this analysis.

^f mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating herds) divided by PCU.

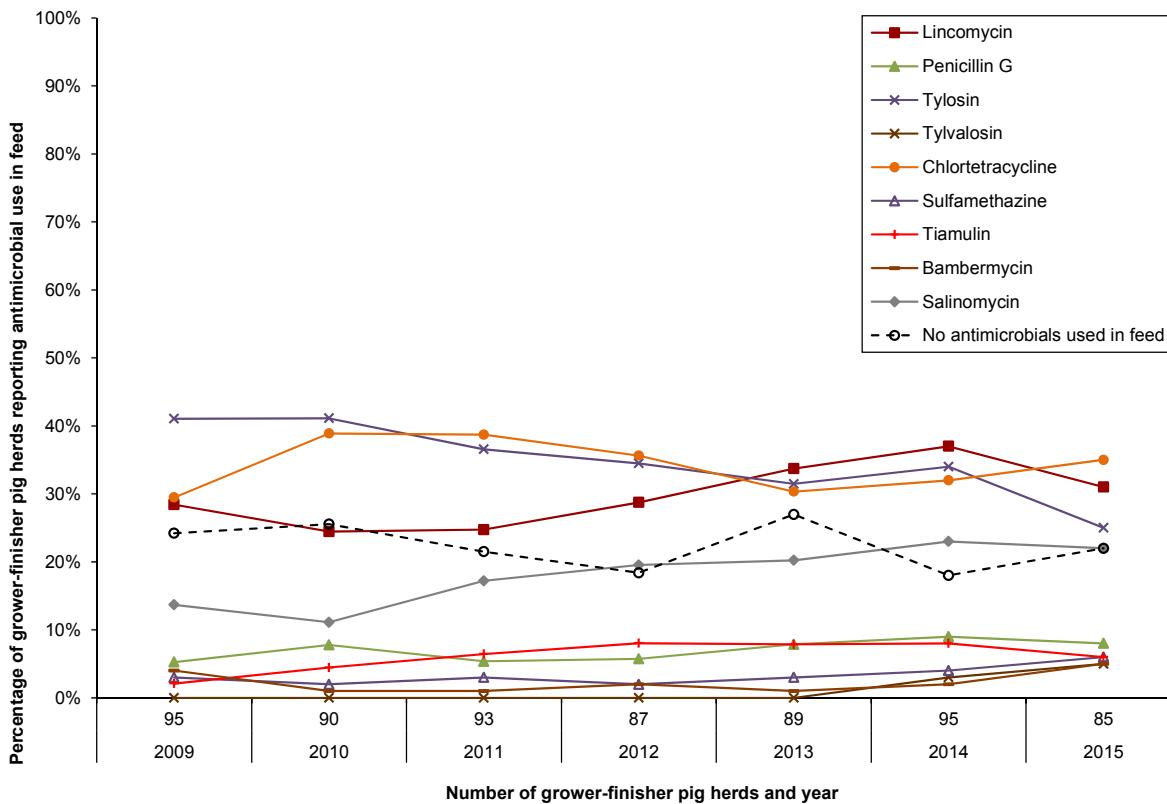
^g Herd level nDDDvetCA/1,000 pig-days = (Estimated quantity of antimicrobials consumed through feed/DDDVetCA)/(Total number of pigs at risk across herd GFPs/1,000) x Total Days across all GFPs. GFP = grower-finisher pig.

^h nDDDvetCA/1,000 pig-days = number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials adjusted for DDDvetCA) divided by 1,000 pig-days (adjusted for population and days in the grow-out period).

²⁷ National Research Council. 2012. Nutrient Requirements of Swine, Eleventh Edition. Washington, DC: National Academy Press.

ANTIMICROBIAL USE IN FEED—FREQUENCY AND PRIMARY REASONS FOR USE

Figure 3. 32 Percentage of grower-finisher pig herds reporting antimicrobial use in feed, 2009–2015



Year Number of herds	2009 95	2010 90	2011 93	2012 87	2013 89	2014 95	2015 85
Antimicrobial							
II	Lincomycin 28%	24%	25%	29%	34%	37%	31%
	Penicillin G 5%	8%	5%	6%	8%	9%	8%
III	Tylosin 41%	41%	37%	34%	31%	34%	25%
	Tylvalosin 0%	0%	0%	0%	0%	3%	5%
IV	Chlortetracycline 29%	39%	39%	36%	30%	32%	35%
	Sulfamethazine 3%	2%	3%	2%	3%	4%	6%
	Tiamulin 2%	4%	6%	8%	8%	8%	6%
IV	Bambermycin 4%	1%	1%	2%	1%	2%	5%
	Salinomycin 14%	11%	17%	20%	20%	23%	22%
	No antimicrobials used in feed 24%	26%	22%	18%	27%	18%	22%

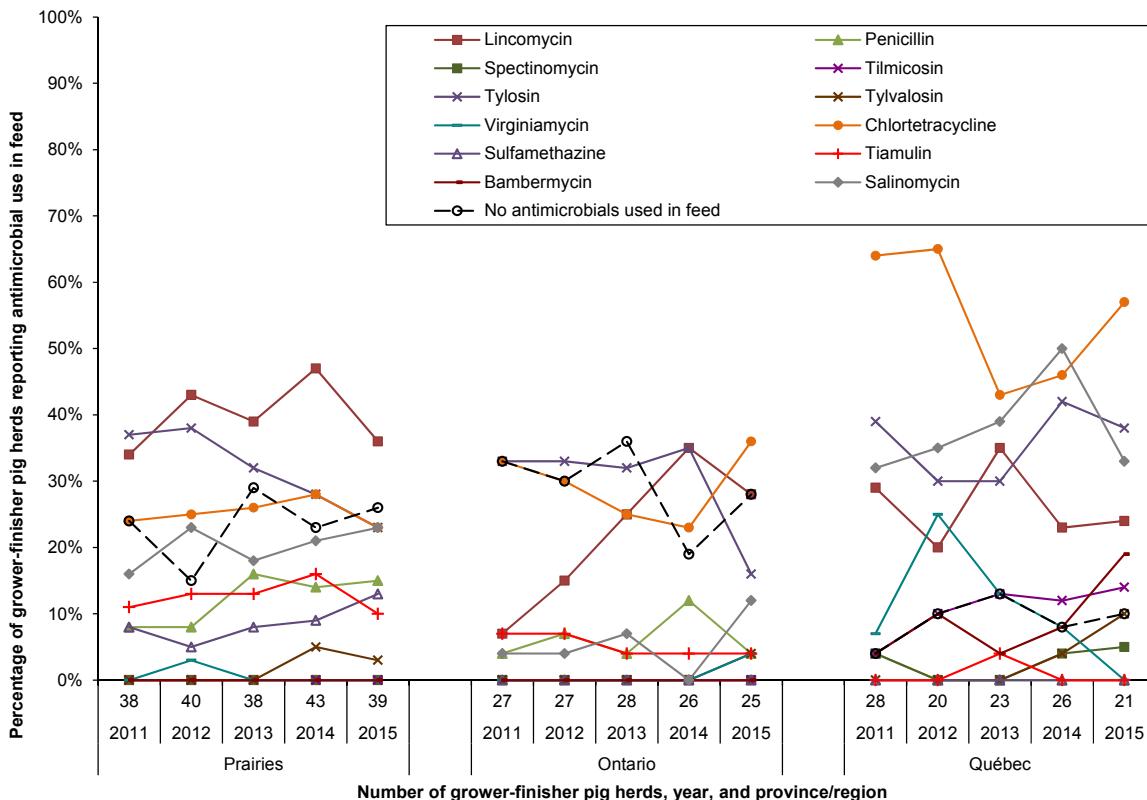
Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Only antimicrobials used by 5% of herds or more in a given year are depicted in this figure. Antimicrobial use in feed reported by fewer than 5% of herds included Category II: tilmicosin, virginiamycin; Category III: bacitracin, neomycin, oxytetracycline, spectinomycin.

For the temporal analyses, the proportion (%) of herds using a specific antimicrobial in the current year has been compared to the proportion (%) of herds using the same antimicrobial in 2009 and the previous surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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Figure 3.33 Percentage of grower-finisher pig herds reporting antimicrobial use in feed by province/region, 2011–2015



Province/region	Year	Prairies					Ontario					Québec				
		2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Number of herds		38	40	38	43	39	27	27	28	26	25	28	20	23	26	21
Antimicrobial																
Lincomycin		34%	43%	39%	47%	36%	7%	15%	25%	35%	28%	29%	20%	35%	23%	24%
Penicillin		8%	8%	16%	14%	15%	4%	7%	4%	12%	4%	4%	0%	0%	0%	0%
Spectinomycin		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	4%	5%	0%
II Tilmicosin		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	10%	13%	12%	14%
Tylosin		37%	38%	32%	28%	23%	33%	33%	32%	35%	16%	39%	30%	30%	42%	38%
Tyvalosin		0%	0%	0%	5%	3%	0%	0%	0%	0%	4%	0%	0%	4%	10%	0%
Virginiamycin		0%	3%	0%	0%	0%	0%	0%	0%	0%	4%	7%	25%	13%	8%	0%
Chlortetracycline		24%	25%	26%	28%	23%	33%	30%	25%	23%	36%	64%	65%	43%	46%	57%
III Sulfamethazine		8%	5%	8%	9%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tiamulin		11%	13%	13%	16%	10%	7%	7%	4%	4%	4%	0%	0%	4%	0%	0%
IV Bambermycin		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	10%	4%	8%	19%
Salinomycin		16%	23%	18%	21%	23%	4%	4%	7%	0%	12%	32%	35%	39%	50%	33%
No antimicrobials used in feed		24%	15%	29%	23%	26%	33%	30%	36%	19%	28%	4%	10%	13%	8%	10%

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

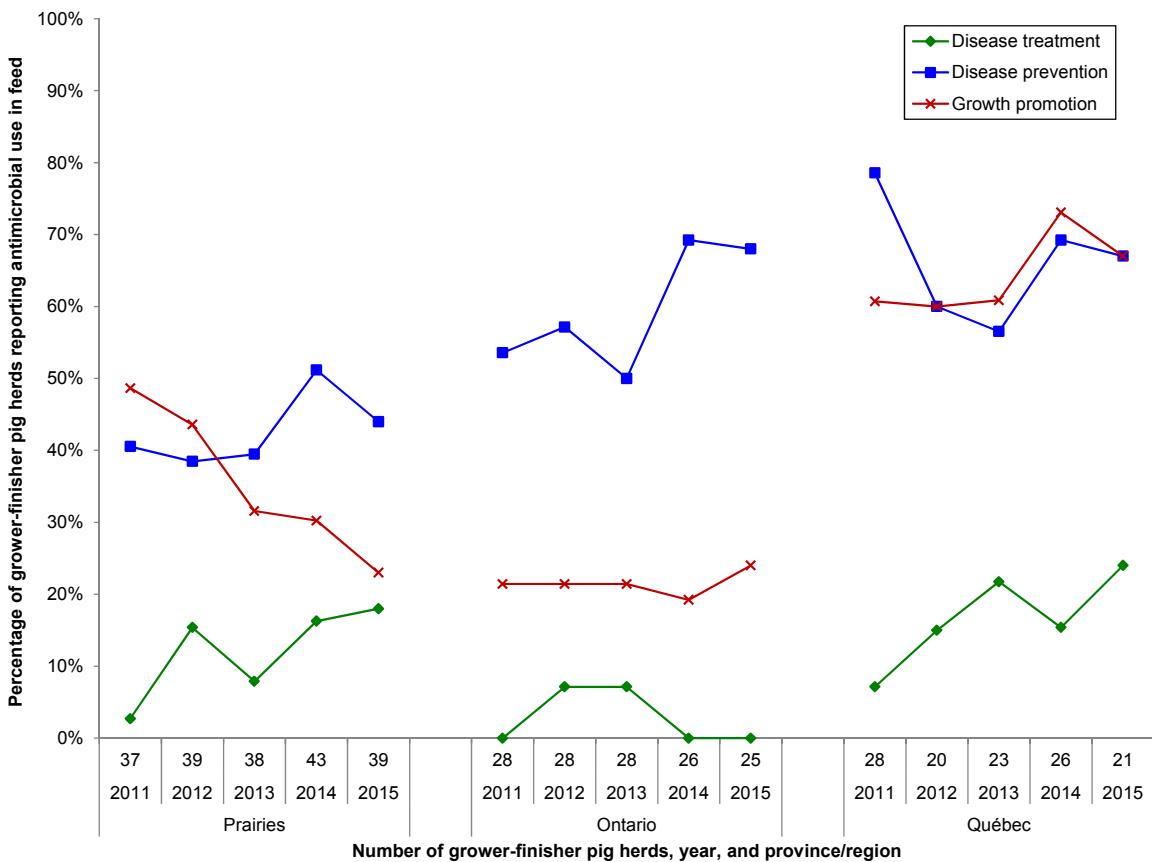
Only antimicrobials used by 5% of herds or more in a given year within any province/region are depicted in this figure. Antimicrobial use in feed reported by fewer than 5% of herds included Category III: bacitracin, neomycin, oxytetracycline, and spectinomycin.

For the temporal analyses within province/region, the proportion (%) of flocks using a specific antimicrobial in the current year has been compared to the proportion (%) of flocks using the same antimicrobial in 2011 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

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Figure 3. 34 Percentage of grower-finisher pig herds reporting antimicrobial use in feed by primary reason for use and province/region, 2011–2015

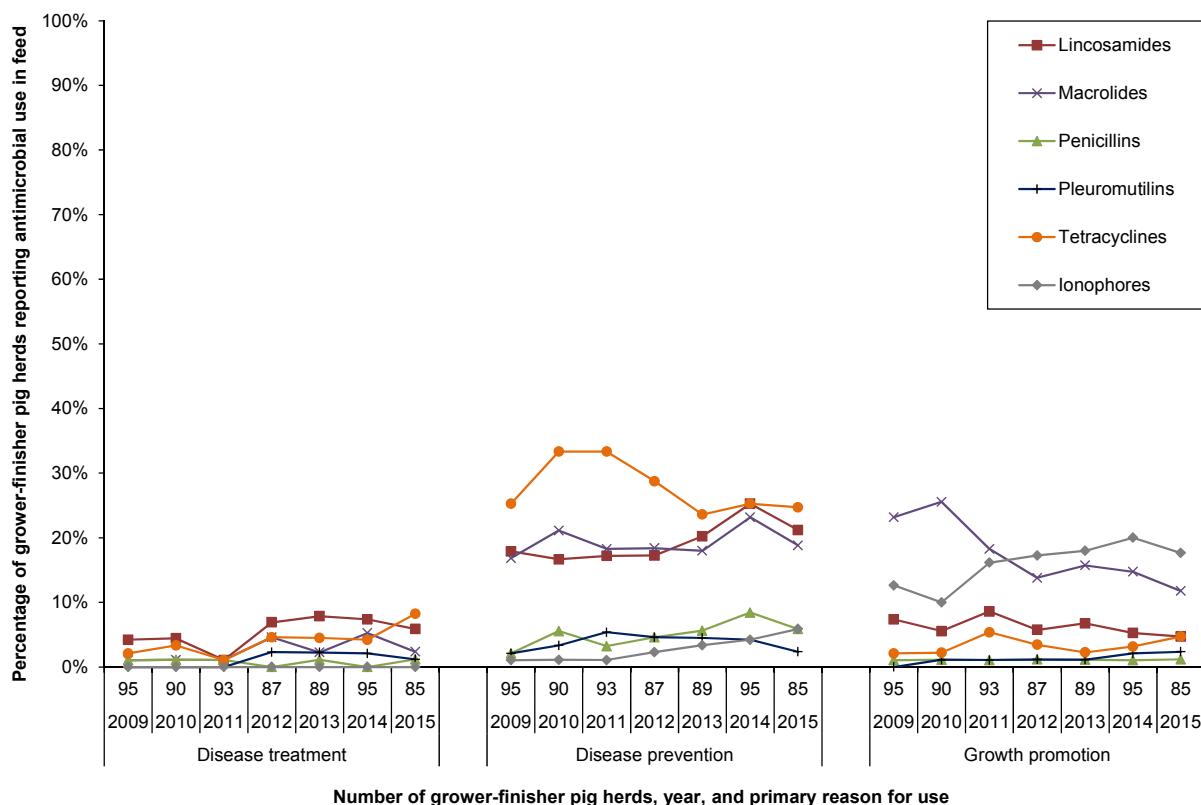


Province/region Year Number of herds	Prairies					Ontario					Québec				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
	38	39	38	43	39	28	28	28	26	25	28	20	23	26	21
Disease treatment	3%	15%	8%	16%	18%	0%	7%	7%	0%	0%	7%	15%	22%	15%	24%
Disease prevention	39%	38%	39%	51%	44%	54%	57%	50%	69%	68%	79%	60%	57%	69%	67%
Growth promotion	47%	44%	32%	30%	23%	21%	21%	21%	19%	24%	61%	60%	61%	73%	67%

Respondents were instructed to select only one of "Disease treatment", "Disease prevention" or "Growth promotion" as a primary reason for use of an antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 3. 35 Percentage of grower-finisher pig herds reporting antimicrobial use in feed by primary reason for use, 2009–2015



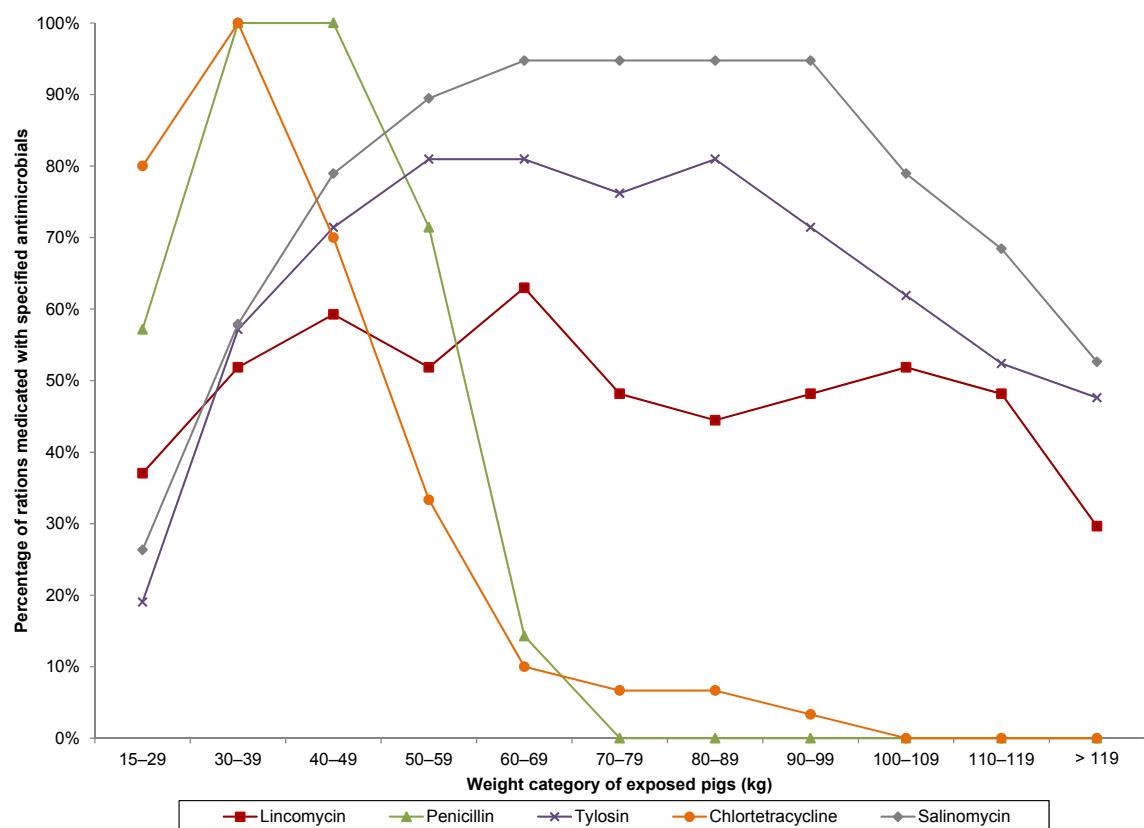
Reason for use	Disease treatment							Disease prevention							Growth promotion						
	2009 95	2010 90	2011 93	2012 87	2013 89	2014 95	2015 85	2009 95	2010 90	2011 93	2012 87	2013 89	2014 95	2015 85	2009 95	2010 90	2011 93	2012 87	2013 89	2014 95	2015 85
Antimicrobial class																					
I Lincosamides	4%	4%	1%	7%	8%	7%	6%	18%	17%	17%	17%	20%	25%	21%	7%	6%	9%	6%	7%	5%	5%
II Macrolides	1%	1%	1%	5%	2%	5%	2%	17%	21%	18%	18%	18%	23%	19%	23%	26%	18%	14%	16%	15%	12%
III Penicillins	1%	1%	1%	0%	1%	0%	1%	2%	6%	3%	5%	6%	8%	6%	1%	1%	1%	1%	1%	1%	1%
IV Pleuromutilins	0%	0%	0%	2%	2%	2%	1%	2%	3%	5%	5%	4%	4%	2%	0%	1%	1%	1%	1%	2%	2%
V Tetracyclines	2%	3%	1%	5%	4%	4%	8%	25%	33%	33%	29%	24%	25%	25%	2%	2%	5%	3%	2%	3%	5%
VI Ionophores	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	2%	3%	4%	6%	13%	10%	16%	17%	18%	20%	18%

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Respondents were instructed to select only one of "Disease treatment", "Disease prevention" or "Growth promotion" as a primary reason for use of an antimicrobial.

Only antimicrobials used by 5% of herds or more in a given year are depicted in this figure.

Figure 3. 36 Percentage of rations medicated with specific antimicrobials fed over the grow-finish period by pig weight category, 2015

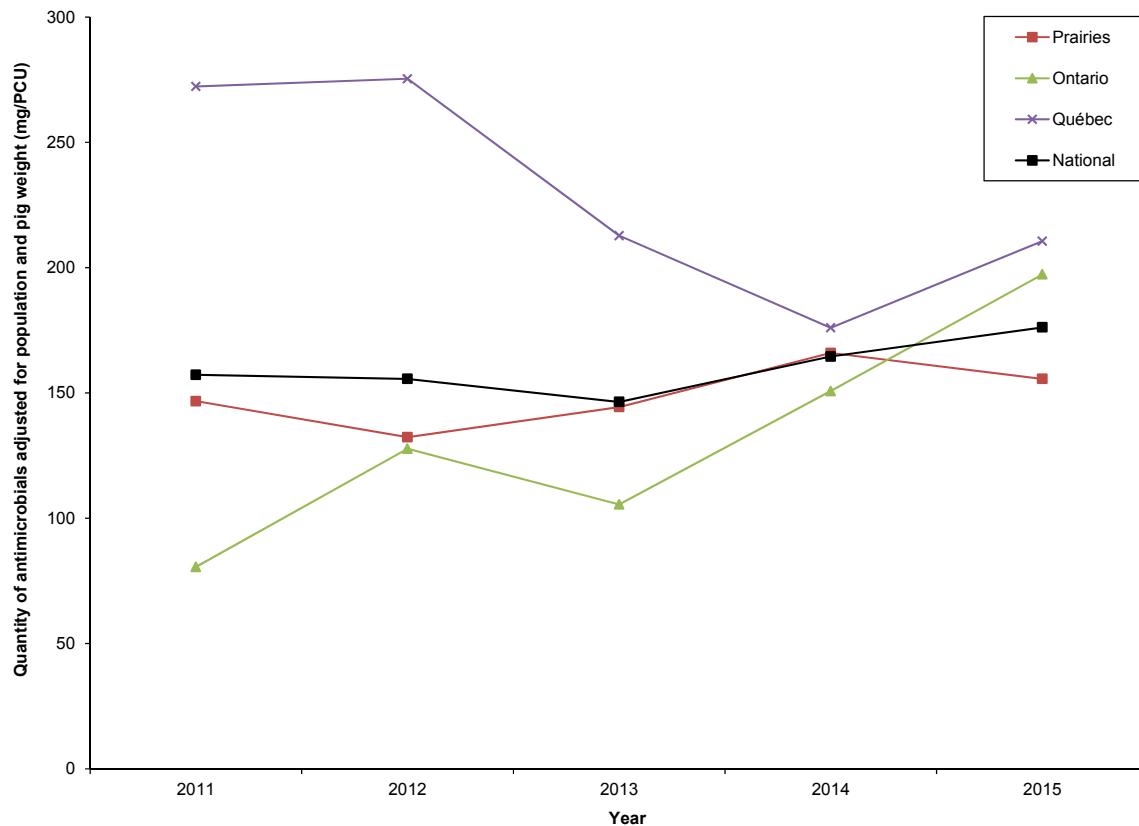


Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Only antimicrobials used in feed by 5% of herds or more in a given year are depicted in this figure. Antimicrobials used in medicated rations by fewer than 5% of herds included Category II: tilmicosin, tylvalosin and virginiamycin; Category III: oxytetracycline, spectinomycin, sulfamethazine and tiamulin; Category IV: bambemycin and narasin.

ANTIMICROBIAL USE IN FEED—QUANTITATIVE METRICS

Figure 3. 37 Quantity of antimicrobial use in feed adjusted for population and pig weight (mg/PCU) by province/region, 2011–2015



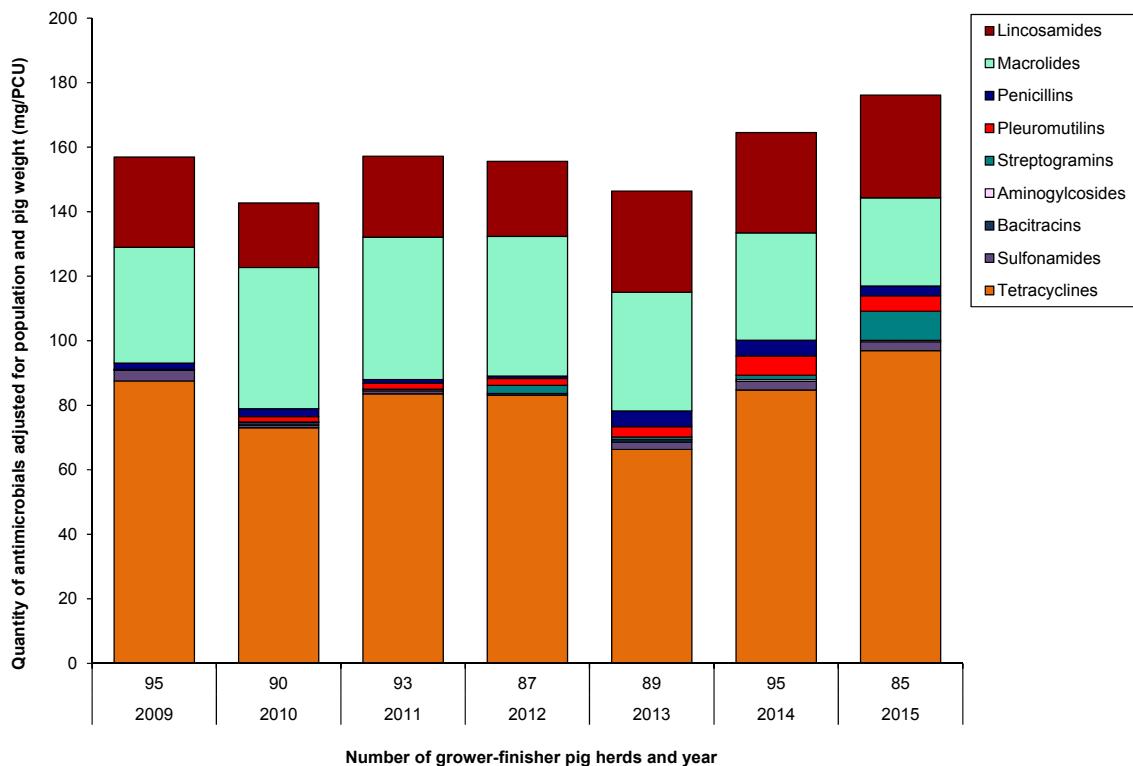
Excluded from this analysis were antimicrobials with growth promotion doses only: bambomycin, narasin and, salinomycin.

mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating herds) divided by PCU.
PCU = population correction unit; total number of pigs in the sampled grower-finisher herds x 65 kg/pig (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Figure 3.38 Quantity of antimicrobial use in feed adjusted for population and pig weight (mg/PCU), 2009–2015



Year	2009	2010	2011	2012	2013	2014	2015
Number of herds	95	90	93	87	89	95	85
Antimicrobial class							
I Lincosamides	28.0	20.1	25.1	23.2	31.3	31.1	31.9
II Macrolides	35.9	43.7	44.2	43.3	36.8	33.2	27.3
III Penicillins	2.0	2.5	1.2	0.8	4.9	4.9	3.0
Pleuromutilins	0.0	1.7	1.8	2.1	3.2	6.0	4.7
Streptogramins	0.0	0.0	0.1	2.6	0.8	1.3	9.0
Aminoglycosides	0.2	0.1	0.4	0.0	0.0	0.6	0.4
Bacitracins	0.0	0.8	0.0	0.0	0.8	0.0	0.0
Sulfonamides	3.3	0.8	0.9	0.5	2.3	2.7	2.7
Tetracyclines	87.5	73.0	83.6	83.1	66.3	84.7	97.0
Subtotal	157.0	142.7	157.2	155.6	146.4	164.5	176.2
IV Flavophospholipids	0.1	0.1	< 0.01	0.1	< 0.01	0.1	0.1
Ionophores	8.7	8.0	17.3	23.3	18.2	16.2	89.5
Subtotal	8.8	8.1	17.3	23.4	18.2	16.2	89.6
Total	165.8	150.9	174.6	179.0	164.6	180.8	265.8

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Excluded from this figure, but included in the table, were antimicrobial classes with growth promotant doses only: flavophospholipids and ionophores.

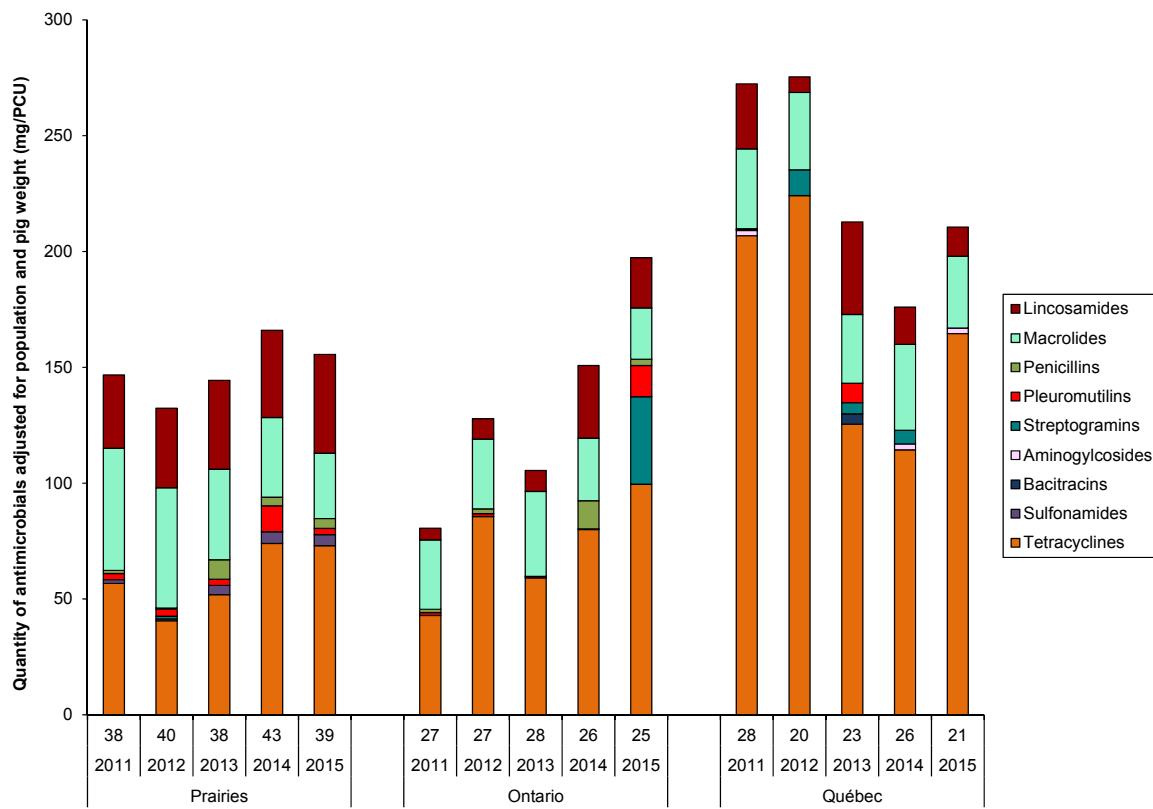
mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating herds) divided by PCU.

PCU = population correction unit; total number of pigs in the sampled grower-finisher herds x 65 kg/pig (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

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Figure 3.39 Quantity of antimicrobials adjusted for population and pig weight (mg/PCU) by province/region, 2011–2015



Province/region	Prairies					Ontario					Québec								
	Year		2011	2012	2013	2014	2015	2011		2012	2013	2014	2015	2011		2012	2013	2014	2015
	Number of herds		38	40	38	43	39	27	27	28	26	25	28	20	23	26	21		
Antimicrobial class																			
I Lincosamides	32	34	38	38	43			5	9	9	31	22			28	7	40	16	13
Macrolides	53	52	39	34	28			30	30	37	27	22			34	33	30	37	31
II Penicillins	1	< 1	8	4	4			1	2	< 0.1	12	3			< 1	0	0	0	0
Pleuromutilins	3	3	3	11	3			1	1	1	< 1	13			0	0	8	0	0
Streptogramins	0	1	0	0	0			0	0	0	0	38			< 1	11	5	6	0
Aminoglycosides	0	0	0	0	0			0	0	0	0	0			2	0	0	3	2
III Bacitracins	0	0	0	0	0			0	0	0	0	0			0	0	4	0	0
Sulfonamides	2	1	4	5	5			0	0	0	0	0			0	0	0	0	0
Tetracyclines	57	41	52	74	73			43	86	59	80	100			207	224	125	114	165
Subtotal	147	132	144	166	156			81	128	106	151	197			272	275	213	176	211
IV Flavophospholipids	0	0	0	0	0			0	0	0	0	0			< 0.1	1	6	67	1
Ionophores	12	20	17	13	138			24	24	4	0	7			26	34	42	40	46
Subtotal	12	20	17	13	138			24	24	4	0	7			26	35	49	106	47
Total	159	152	162	179	294			105	152	109	151	205			298	310	261	282	259

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Excluded from this figure, but included in the table, were antimicrobial classes with growth promotant doses only: flavophospholipids and ionophores.

mg/PCU = mg (total milligrams of active ingredient consumed in feed by participating herds) divided by PCU.

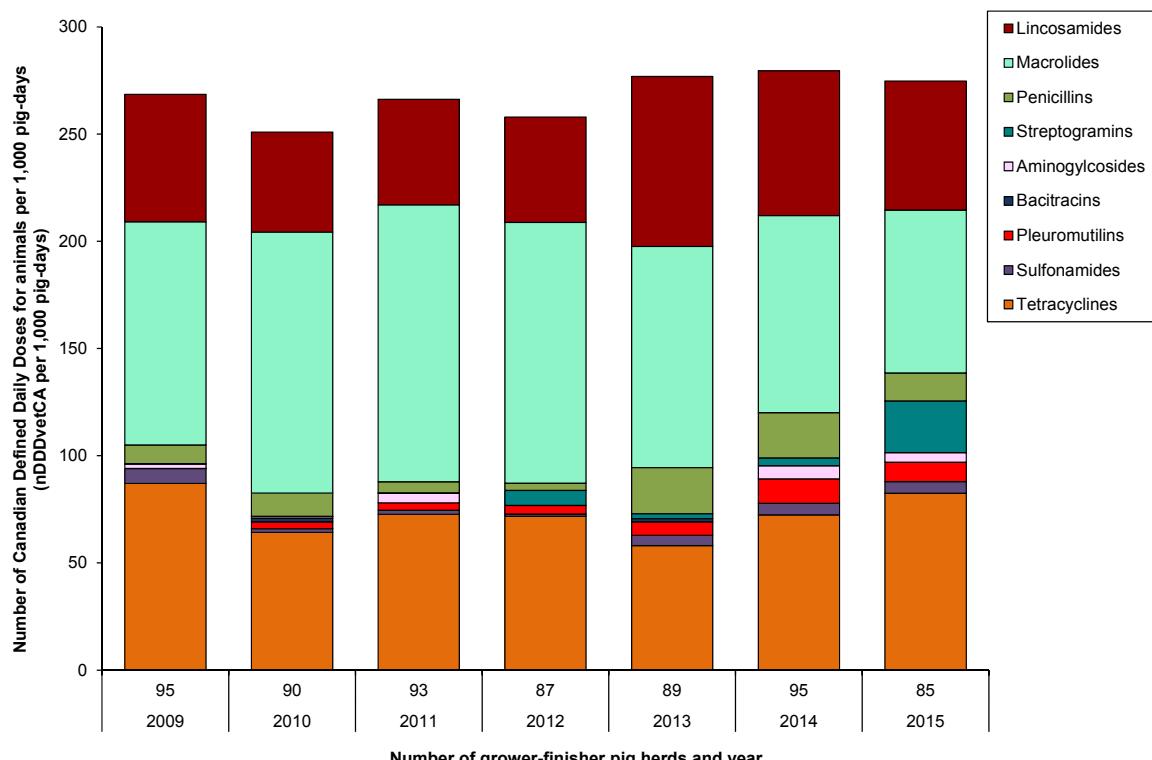
PCU = population correction unit; total number of pigs in the sampled grower-finisher herds x 65 kg/pig (ESVAC weight).

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

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**Figure 3. 40 Number of Canadian Defined Daily Doses for animals per 1,000 pig-days
(nDDDvetCA/1,000 pig-days) for antimicrobials administered in feed, 2009–2015**



Year	2009	2010	2011	2012	2013	2014	2015
Number of herds	95	90	93	87	89	95	85
Antimicrobial							
I Lincosamides	59	47	49	49	79	68	60
II Macrolides	104	122	129	122	103	92	76
Penicillins	9	11	5	3	21	21	13
Streptogramins	< 0.1	< 0.1	< 1	7	2	4	24
Aminoglycosides	2	1	4	0	0	6	4
Bacitracins	0	2	0	0	2	0	0
III Pleuromutilins	< 0.1	3	4	4	6	11	9
Sulfonamides	7	2	2	1	5	5	5
Tetracyclines	87	64	73	72	58	72	82
Subtotal	268	251	266	258	277	280	275
IV Flavophospholipids	1,077	892	60	860	8	648	926
Ionophores	80	72	157	209	166	144	795
Subtotal (not in figure)	1,157	964	217	1,069	175	792	1,721
Total	1,425	1,215	483	1,327	452	1,071	1,995

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

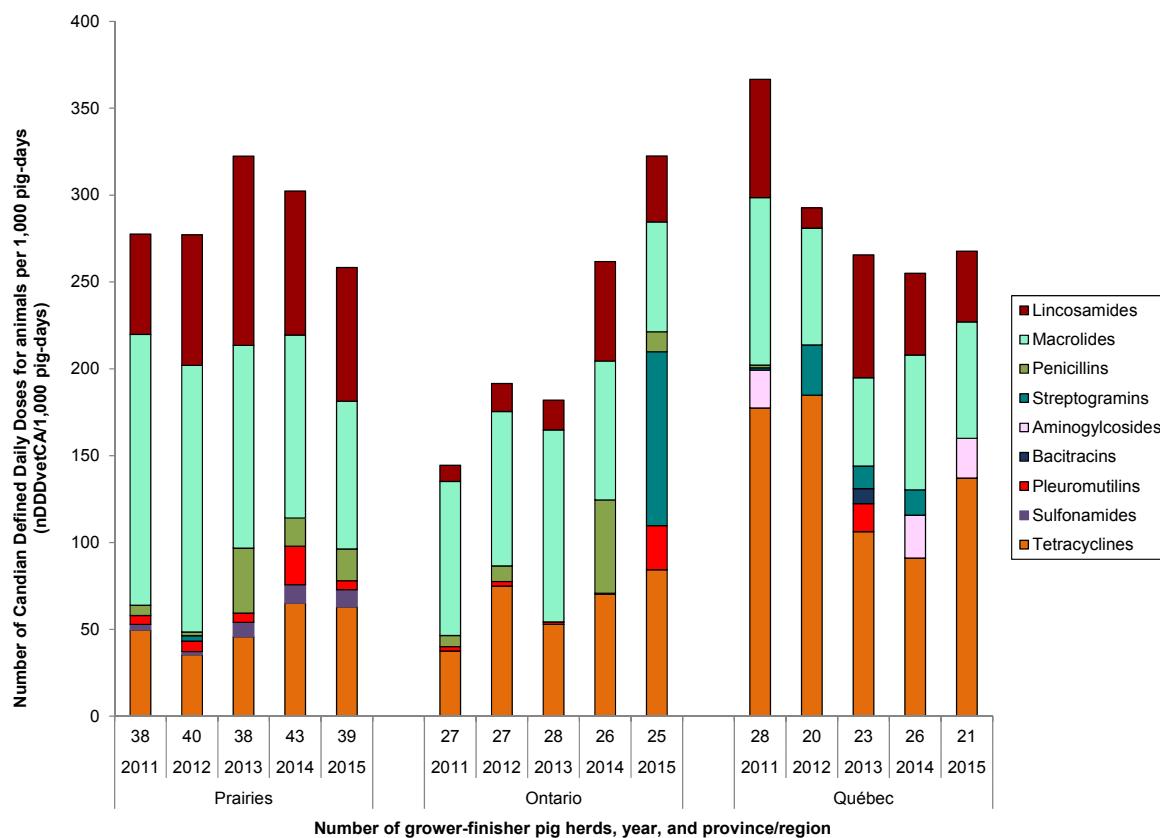
Included in this analysis, but not depicted in the figure, were Category IV antimicrobials with growth promotant doses only: bambemycin, narasin and salinomycin.

nDDDvetCA/1,000 pig-days = Number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials in feed adjusted for DDDvetCA) divided by 1,000 pig-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram pig ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

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**Figure 3. 41 Number of Canadian Defined Daily Doses for animals per 1,000 pig-days
(nDDDvetCA/1,000 pig-days) for antimicrobials administered in feed, by province/region, 2011–2015**



Province/Region	Year	Prairies					Ontario					Québec				
		2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Number of herds		38	40	38	43	39	27	27	28	26	25	28	20	23	26	21
Antimicrobial																
I Lincosamides		58	75	109	83	77	9	16	17	57	38	68	12	71	47	41
II Macrolides		156	154	117	105	85	89	89	111	80	63	96	67	51	78	67
Penicillins		6	2	37	16	18	6	9	0	54	12	2	0	0	0	0
Streptogramins		0	3	0	0	0	0	0	0	0	100	1	29	13	15	0
Aminoglycosides		0	0	0	0	0	0	0	0	0	0	22	0	0	25	23
Bacitracins		0	0	0	0	0	0	0	0	0	0	0	0	9	0	0
III Pleuromutilins		5	6	5	22	5	2	3	1	1	25	0	0	16	0	0
Sulfonamides		3	2	8	11	10	0	0	0	0	0	0	0	0	0	0
Tetracyclines		50	35	46	65	63	38	75	53	70	84	177	185	106	91	137
Subtotal		278	277	322	302	258	144	192	182	262	322	367	293	266	255	268
IV Flavophospholipids		0	0	0	0	0	0	0	0	0	0	297	4,812	48	2,622	4,710
Ionophores		109	181	159	123	1,244	221	218	36	0	64	228	291	372	328	425
Subtotal (not in figure)		109	181	159	123	1,244	221	218	36	0	64	525	5,103	420	2,950	5,136
Total		386	459	482	425	1,502	365	409	218	262	386	891	5,396	685	3,205	5,403

Roman numerals II to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Included in this analysis, but not depicted in the figure, were Category IV antimicrobials with growth promotant doses only: bambermycin, narasin and salinomycin.

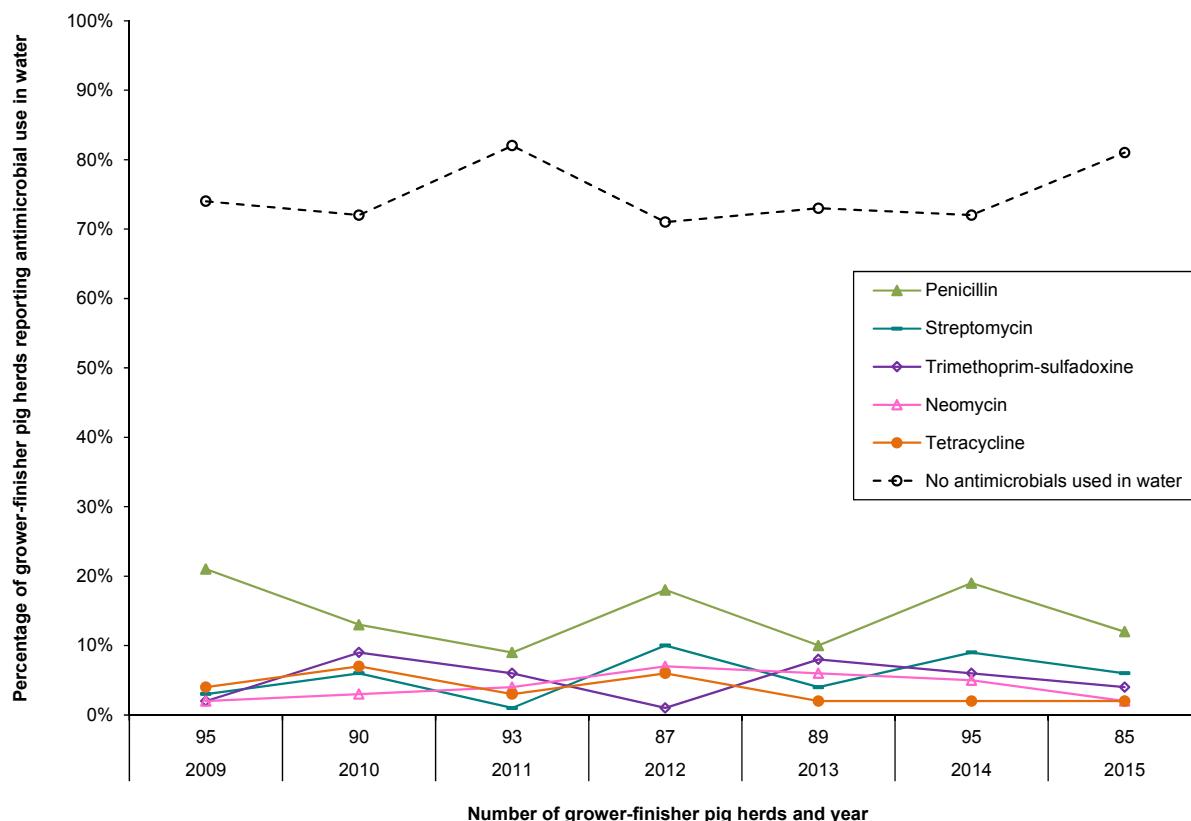
nDDDvetCA/1,000 pig-days = Number of Canadian Defined Daily Doses for animals (pertains to the quantity of antimicrobials in feed adjusted for DDDvetCA) divided by 1,000 pig-days (adjusted for population and days in the grow-out period).

DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram pig ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$). The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

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ANTIMICROBIAL USE IN WATER—FREQUENCY

Figure 3. 42 Percentage of grower-finisher pig herds reporting antimicrobial use in water, 2009–2015



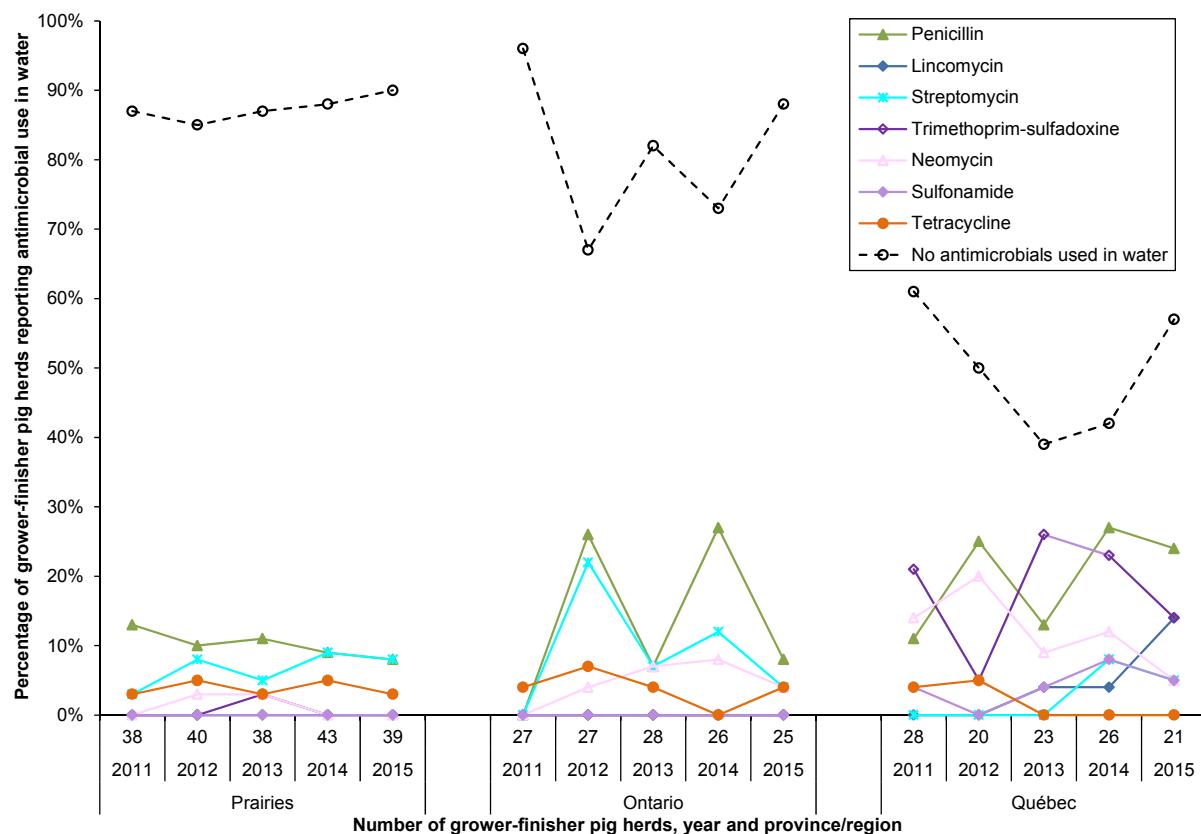
Year	2009	2010	2011	2012	2013	2014	2015
Number of herds	95	90	93	87	89	95	85
Antimicrobial							
Penicillin	21%	13%	9%	18%	10%	19%	12%
Streptomycin	3%	6%	1%	10%	4%	9%	6%
Trimethoprim-sulfadoxine	2%	9%	6%	1%	8%	6%	4%
Neomycin	2%	3%	4%	7%	6%	5%	2%
Tetracycline	4%	7%	3%	6%	2%	2%	2%
No antimicrobials used in water	74%	72%	82%	71%	73%	72%	81%

Roman numerals II to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Only antimicrobials used by 5% of herds or more in a given year are depicted in this figure. Antimicrobial use in water reported by fewer than 5% of herds included Category II: lincomycin; Category III: spectinomycin and sulfonamide.

For the temporal analyses, the proportion (%) of herds using a specific antimicrobial in the current year has been compared to the proportion (%) of herds using the same antimicrobial in 2009 and the previous surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 3.43 Percentage of grower-finisher pig herds reporting antimicrobial use in water by province/region, 2011–2015



Province/region		Prairies					Ontario					Québec				
Year	Number of herds	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Antimicrobial		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	4%	14%
I	Lincomycin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	25%	13%	27%	24%
II	Penicillin	13%	10%	11%	9%	8%	0%	26%	7%	27%	8%	0%	0%	0%	8%	5%
III	Streptomycin	3%	8%	5%	9%	8%	0%	22%	7%	12%	4%	0%	0%	0%	8%	5%
	Trimethoprim-sulfadoxine	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	21%	5%	26%	23%	14%
	Neomycin	0%	3%	3%	0%	0%	0%	4%	7%	8%	4%	0%	20%	9%	12%	5%
	Sulfonamide	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	4%	8%	5%
	Tetracycline	3%	5%	3%	5%	3%	4%	7%	4%	0%	4%	4%	5%	0%	0%	0%
	No antimicrobials used in water	87%	85%	87%	88%	90%	96%	67%	82%	73%	88%	61%	50%	39%	42%	57%

Roman numerals II to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs

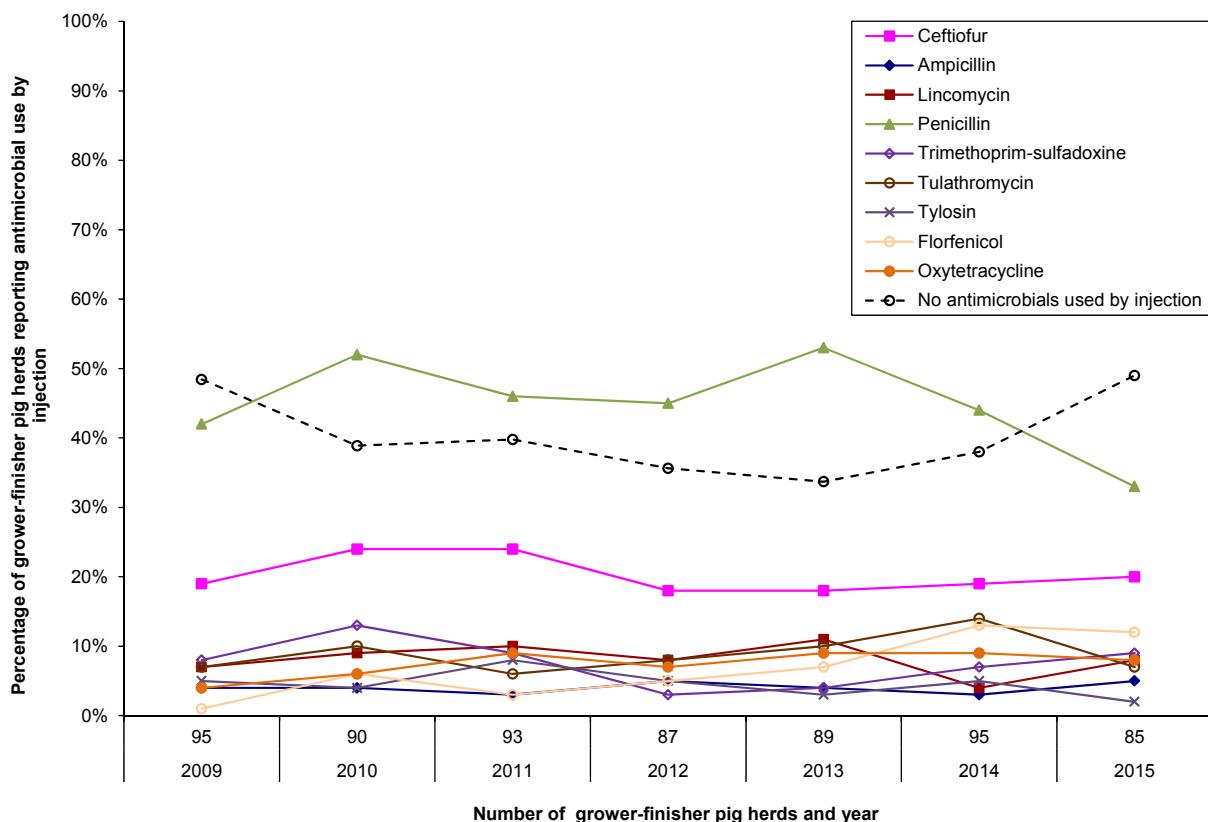
Only antimicrobials used by 5% of herds or more in a given year within any province/region are depicted in this figure. Antimicrobial use in water reported by fewer than 5% of herds included Category III: spectinomycin.

For the temporal analyses, the proportion (%) of herds using a specific antimicrobial in the current year has been compared to the proportion (%) of herds using the same antimicrobial in 2011 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

ANTIMICROBIAL USE BY INJECTION—FREQUENCY

Figure 3. 44 Percentage of grower-finisher pig herds reporting antimicrobial use by injection, 2009–2015



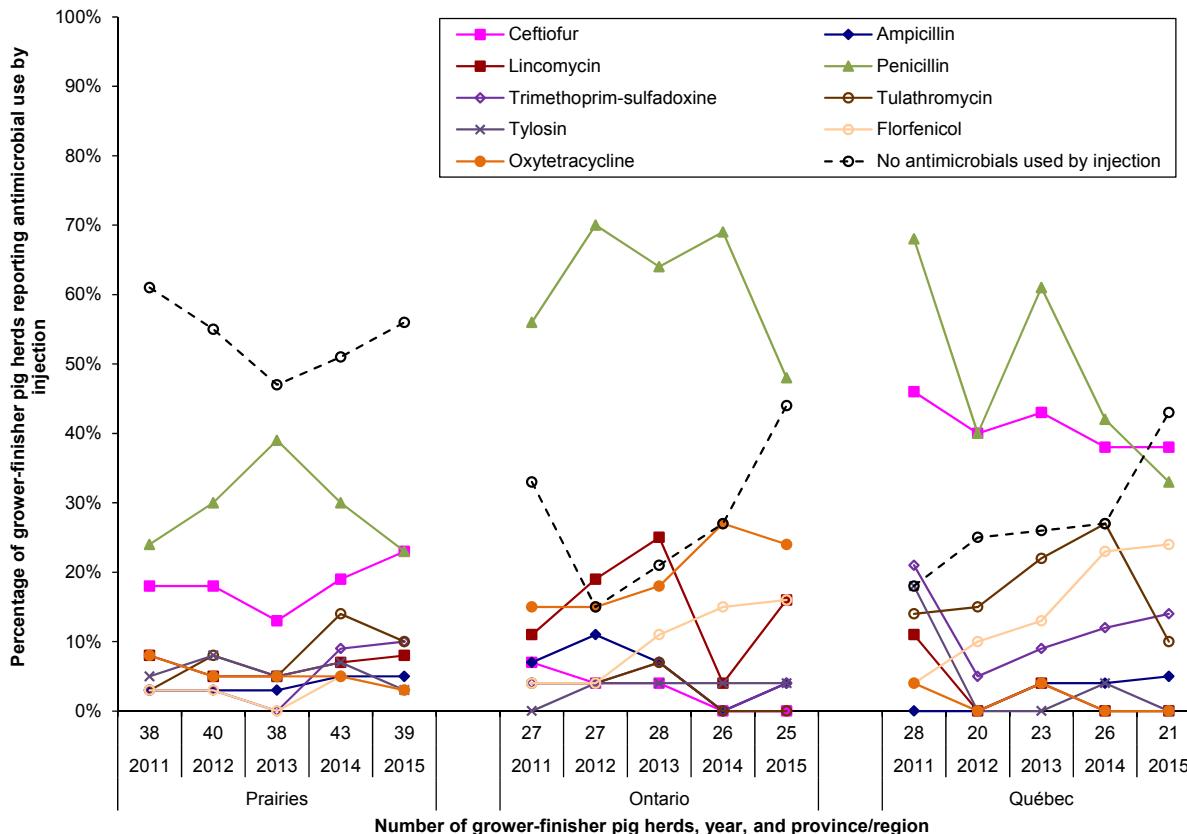
Year Number of herds	2009 95	2010 90	2011 93	2012 87	2013 89	2014 95	2015 85
Antimicrobial							
I Ceftiofur	20%	24%	24%	18%	18%	19%	20%
Ampicillin	4%	4%	3%	5%	4%	3%	5%
Lincomycin	8%	9%	10%	8%	11%	4%	8%
II Penicillin	41%	51%	46%	45%	53%	44%	33%
III Trimethoprim-sulfadoxine	9%	13%	9%	3%	4%	7%	9%
Tulathromycin	8%	10%	6%	8%	10%	14%	7%
Tylosin	5%	4%	8%	5%	3%	5%	2%
Florfenicol	1%	6%	3%	5%	7%	13%	12%
Oxytetracycline	4%	6%	9%	7%	9%	9%	8%
No antimicrobials used by injection	47%	40%	40%	36%	34%	38%	49%

Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Only antimicrobials used by 5% of herds or more in a given year are depicted in this figure.

For the temporal analyses, the proportion (%) of herds using a specific antimicrobial in the current year has been compared to the proportion (%) of herds using the same antimicrobial in 2009 and the previous surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 3.45 Percentage of grower-finisher pig herds reporting antimicrobial use by injection and province/region, 2011–2015



Province/region		Prairies					Ontario					Québec				
Year	Number of herds	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Antimicrobial I																
I. Ceftiofur	18%	18%	13%	19%	23%	7%	4%	4%	0%	0%	46%	40%	43%	38%	38%	
Ampicillin	3%	3%	3%	5%	5%	7%	11%	7%	0%	4%	0%	0%	4%	4%	5%	
Lincomycin	8%	5%	5%	7%	8%	11%	19%	25%	4%	16%	11%	0%	4%	0%	0%	
II																
Penicillin	24%	30%	39%	30%	23%	56%	70%	64%	69%	48%	68%	40%	61%	42%	33%	
Trimethoprim-sulfadoxine	3%	3%	0%	9%	10%	4%	4%	7%	0%	4%	21%	5%	9%	12%	14%	
Tulathromycin	3%	8%	5%	14%	10%	4%	4%	7%	0%	0%	14%	15%	22%	27%	10%	
Tylosin	5%	8%	5%	7%	3%	0%	4%	4%	4%	4%	18%	0%	0%	4%	0%	
III																
Florfenicol	3%	3%	0%	5%	3%	4%	4%	11%	15%	16%	4%	10%	13%	23%	24%	
Oxytetracycline	8%	5%	5%	5%	3%	15%	15%	18%	27%	24%	4%	0%	4%	0%	0%	
No antimicrobials used by injection	24%	15%	29%	23%	56%	33%	30%	36%	19%	44%	4%	10%	13%	8%	43%	

Roman numerals I to III indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

Only antimicrobials used by 5% of herds or more in a given year within any province/region are depicted in this figure. Antimicrobial use by injection reported by fewer than 5% of herds included Category II: erythromycin; Category III: spectinomycin and tiamulin.

For the temporal analyses, the proportion (%) of herds using a specific antimicrobial in the current year has been compared to the proportion (%) of herds using the same antimicrobial in 2011 and the previous surveillance year (grey areas). The presence of blue areas indicates significant temporal differences within province/region ($P \leq 0.05$) for a given antimicrobial. The presence of red areas indicates significant provincial/regional differences ($P \leq 0.05$) for a given antimicrobial within the current year. The presence of purple areas indicates significant temporal and provincial/regional differences ($P \leq 0.05$) for a given antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

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

CHAPTER 4—ANTIMICROBIAL RESISTANCE



HUMAN SURVEILLANCE

KEY FINDINGS

The Provincial Public Health Laboratories forwarded a total of 2,519 *Salmonella* isolates (185 serovars) that underwent susceptibility testing at the National Microbiology Laboratory, Public Health Agency of Canada.

***SALMONELLA* (n = 2,519)**

Susceptibility testing was routinely carried out on 8 serovars: Enteritidis, Heidelberg, 4,[5],12:i:-, Newport, Paratyphi A, Paratyphi B, Typhi and Typhimurium (2,318 isolates)²⁸. In addition, 201 isolates of other *Salmonella* serovars were also tested.

The most commonly isolated serovars in 2015 were Enteritidis (47%, 1,188/2,519), Heidelberg (12%, 308/2,519), and Typhimurium (12%, 291/2,519) (Table 4. 1).

Data about sample source was complete for 2,500 isolates. Most isolates (79%, 1,981/2,500) were recovered from stool samples. Ten percent (240/2,500) of isolates were recovered from blood. Typhoidal isolates (Typhi, Paratyphi A, and Paratyphi B) accounted for a large proportion of these isolates from blood (51%, 122/240). Four percent (93/2,500) of isolates were recovered from urine. In contrast to isolation from blood, typhoidal isolates accounted for a very small proportion of isolates from urine (1%, 1/93). The proportion of isolates recovered from blood, urine, and other sample types varied by serovar (Figure 4. 1).

NON-TYPHOIDAL *SALMONELLA* (n = 2,357)

In 2015, 26% (618/2,357) of all non-typhoidal *Salmonella* isolates were resistant to one or more antimicrobials tested, compared to 25% (620/2,485) in 2014. Twelve percent (286/2,357) of isolates were resistant to a single antimicrobial. Significant increases in resistance among non-typhoidal isolates occurred from 2014 to 2015 for gentamicin (1%, 23/2,485 in 2014 to 2%, 55/2,357 in 2015), nalidixic acid (9%, 212/2,485 in 2014 to 11%, 262/2,357 in 2015), and trimethoprim-sulfamethoxazole (2%, 43/2,485 in 2014 to 3%,

²⁸ Although the agri-food sector is not a source of *Salmonella* Typhi, *S.* Paratyphi A or *S.* Paratyphi B, data for these serovars are also presented because they each cause severe disease in humans.

72/2,357 in 2015). Additionally, a significant increase in resistance to ceftriaxone has been observed since 2006 (5%, 122/2,357 in 2015 and 4% (111/2,975) in 2006), whereas resistance to streptomycin (10%, 242/2,357 in 2015 to 13% (397/2,975) in 2006) and tetracycline (12%, 272/2,357 in 2015 to 16% (486/2,975), in 2006) has dropped since 2006 (Figure 4. 2).

TYPHOIDAL *SALMONELLA* (n = 162)²⁹

In 2015, a total of 77% (125/162) of typhoidal *Salmonella* isolates were resistant to one or more antimicrobials tested. Fifty-nine percent (96/162) of isolates were resistant to a single antimicrobial. A high proportion (76%, 123/162) of typhoidal isolates was resistant to nalidixic acid.

There were no significant changes in resistance from 2014 to 2015. The only significant change in resistance was a decrease in the proportion of isolates resistant to tetracycline since 2006 (8%, 18/230 in 2006 to 1%, 2/162 in 2015) (Figure 4. 3).

ENTERITIDIS (n = 1,188)

In 2015, 4% (50/1,180) of Enteritidis isolates were recovered from blood and 2% (29/1,180) of isolates were recovered from urine. Source information was not available for 8 isolates (Figure 4. 1).

Nineteen percent (227/1,188) of Enteritidis isolates in 2015 were resistant to one or more antimicrobials tested. The most common resistance was to nalidixic acid; 17% (207/1,188) of isolates were resistant to this antimicrobial (Table 4. 1).

Resistance to streptomycin and tetracycline increased significantly in 2015 (2%, 23/1,188 and 3%, 37/1,188, respectively) compared to 2014 (both 1%, 8/1,218, 16/1,218, respectively). Resistance to trimethoprim-sulfamethoxazole increased significantly in 2015 to 3% (30/1,188) compared to 2006 and 2014 (both 1%, 4/710 and 7/1,218, respectively). No other significant changes in resistance were observed to any of the other antimicrobials tested, including nalidixic acid (Figure 4. 4).

HEIDELBERG (n = 308)

In 2015, 12% (36/308) of Heidelberg isolates were recovered from blood and 8% (25/308) of isolates were recovered from urine (Figure 4. 1).

In 2015, 39% (121/308) of Heidelberg isolates were resistant to one or more antimicrobials tested. Twenty-seven percent (83/308) of Heidelberg isolates were resistant to ceftriaxone (Table 4. 1).

Resistance to gentamicin, streptomycin, tetracycline and trimethoprim-sulfamethoxazole increased significantly in 2015 (7%, 22/308; 8%, 24/308; 6%, 17/308 and 3%, 10/308, respectively) compared to 2014 (1%, 5/362; 4%, 14/362; 2%, 9/362 and 1%, 3/362,

²⁹ *Salmonella* Paratyphi B does not include *S. Paratyphi* B var. L (+) tartrate (+), formerly called *S. Paratyphi* var. Java. The biotype of *S. Paratyphi* B included here is tartrate (-) and associated with severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness.

respectively). Resistance was also higher in 2015 compared with 2006 for ceftriaxone (27%, 83/308 and 13%, 57/430, respectively) (Figure 4. 5).

NEWPORT (n = 229)

Two percent (4/226) of Newport isolates were recovered from blood in 2015 and 3% (7/226) from urine. Source information was not available for 3 isolates (Figure 4. 1).

Six percent (13/229) of the Newport isolates were resistant to one or more antimicrobials tested (Table 4. 1). There were no significant changes in resistance in 2015 compared to 2014. However, resistance to ampicillin, ceftriaxone, streptomycin and tetracycline all decreased significantly in 2015 (5%, 11/229; 2%, 5/229; 4%, 10/229 and 5%, 12/229, respectively) compared to 2006 (12%, 18/146; 9%, 13/146; 13%, 19/146; and 18%, 27/146, respectively) (Figure 4. 6).

PARATYPHI A AND PARATYPHI B (n = 36)³⁰

Seventy-five percent (27/36) of Paratyphi A and B isolates were recovered from blood samples (Figure 4. 1).

In 2015, 72% (26/36) of Paratyphi A and B isolates were resistant to one or more antimicrobials tested. Most (69%, 25/36) Paratyphi A and B isolates were resistance to nalidixic acid (Table 4. 1). There were no significant changes in resistance detected in 2015 (Figure 4. 7).

TYPHI (n = 126)

Seventy-five percent (95/126) of Typhi isolates were recovered from blood samples in 2015. Recovery of Typhi from urine remained low in 2015 (less than 1%, 1/126) (Figure 4. 1).

In 2015, 79% (99/126) of Typhi isolates were resistant to one or more antimicrobials tested. Resistance to nalidixic acid was observed in 78% (98/126) of isolates (Table 4. 1). The only significant change in resistance was a decreased in resistance to tetracycline in 2015 (2%, 2/126) compared to 2006 (10%, 17/164) (Figure 4. 8).

TYPHIMURIUM (n = 291)

Three percent (8/288) of Typhimurium isolates in 2015 were recovered from blood samples and 1% (4/288) from urine. Source information was not available for 3 isolates (Figure 4. 1).

In 2015, 34% (98/291) of Typhimurium were resistant to one or more antimicrobials tested. Five percent (14/291) of Typhimurium isolates were resistant to 6 antimicrobial classes; 4% (13/291) of isolates were resistant to all classes tested except the macrolides and less than 1% (1/291) of isolates was resistant to all classes except the tetracyclines (Table 4. 1).

³⁰ *Salmonella* Paratyphi B does not include *S.* Paratyphi B var. L (+) tartrate (+), formerly called *S.* Paratyphi var. Java. The biotype of *S.* Paratyphi B included here is tartrate (-) and associated with severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness.

Resistance to nalidixic acid increased in 2015 (5%, 15/291) compared to 2006 (2%, 11/539) whereas resistance to streptomycin and tetracycline both decreased in 2015 (both 27%, 78/291 and 80/291, respectively) compared to 2006 (36% 195/539 and 38%, 203/539, respectively) (Figure 4. 9).

4,[5],12:i:- (n = 140)

One percent (2/139) of 4,[5],12:i:- isolates were recovered from blood samples in 2015 and 3% (4/139) from urine. Source information was not available for 2 isolates (Figure 4. 1).

In 2015, 70% (98/140) of 4,[5],12:i:- were resistant to one or more antimicrobials tested. Resistance to ampicillin, streptomycin and tetracycline increased in 2015 (51%, 72/140; 53%, 74/140 and 59%, 82/140, respectively) compared to 2006 (26%, 15/57; 16%, 9/57; and 25%, 14/57, respectively). Resistance to ceftriaxone decreased in 2015 (2%, 3/140) compared to 2006 (16%, 9/57) (Figure 4. 10).

OTHER NON-TYPHOIDAL SEROVARS (n = 201)

Among the other non-typhoidal *Salmonella* serovars tested by CIPARS in 2015, the most common were Infantis (n = 138), Kentucky (n = 20) and Dublin (n = 18).

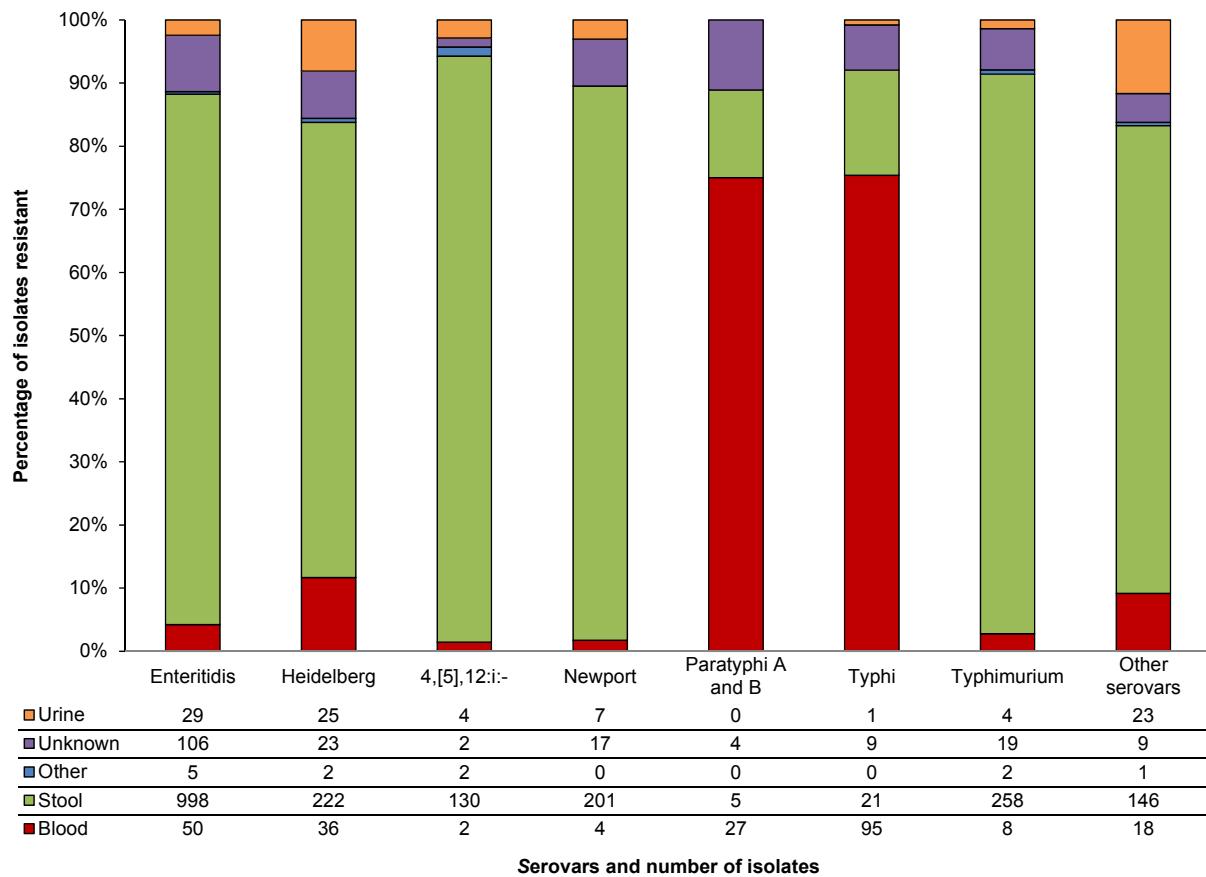
Two of the Infantis isolates (1%) were resistant to 6 antimicrobial classes; these isolates were resistant to all classes tested all except the macrolides. Four percent (6/135) of Infantis isolates were recovered from blood and 7% (9/135) from urine. Source information was not available for 3 isolates.

One of the Kentucky isolates was resistant to all antimicrobial classes tested; 6 isolates were resistant to 5 antimicrobial classes (all classes tested except the macrolides and phenicols). Four Kentucky isolates were recovered from urine, none were recovered from blood.

Five Dublin isolates were resistant to 6 antimicrobial classes tested; these isolates were resistant to all classes tested except the macrolides. An additional 6 isolates were resistant to 5 classes; these isolates were resistant to all classes tested except the macrolides and the quinolones. Eleven Dublin isolates were recovered from blood, none were recovered from urine and source information was not available for 1 isolate.

SEROVAR DISTRIBUTION

Figure 4. 1 Proportion of human *Salmonella* serovars from all sample sources, 2015



Salmonella Paratyphi B does not include *S. Paratyphi* B var. L (+) tartrate (+), formerly called *S. Paratyphi* var. Java. The biotype of *S. Paratyphi* B included here is tartrate (-) and associated with severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness. In 2015, 19 isolates were missing information about sample source.

MULTICLASS RESISTANCE

Table 4. 1 Number of antimicrobial classes in resistance patterns of *Salmonella* from humans, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	Folate pathway inhibitors	Macrolides	Phenicals	Quinolones	Tetracyclines		
British Columbia																				
Enteritidis	162 (53.3)	141	8	8	5		1	6	8					10	5			20	9	
Heidelberg	42 (13.8)	14	23	4	1		2	3	26	16	18	16	16	2	1			1	4	
Newport	33 (10.9)	29	1	3		1	3	4	2	2	2	2	2	3			2		4	
Other serovars	22 (7.2)	18	1	3		1	2	3	1	1	1	1	1	4	1		2	2	3	
Typhi	17 (5.6)	5	10	2			2	2						2	2		2	4	12	
Typhimurium	14 (4.6)	10	1	1	2		1	2	2					3			2	1	2	
4,[5],12:i:-	8 (2.6)	1	1	1	5		1	6	5					6			1		5	
Paratyphi A and B	6 (2.0)	1	5															5		
Total	304 (100)	219	48	16	21		7	24	50	19	21	19	19	30	9		9	6	41	27
Alberta																				
Enteritidis	185 (53.3)	158	12	15				13						1	11		1	24		4
Typhimurium	33 (9.5)	23	5	5			8	5	1	1	1	1	1	10	1		4		6	
4,[5],12:i:-	30 (8.6)	10	7	5	8		12	10						12	1			5	19	
Typhi	28 (8.1)	11	14	3			3	3						3	3		3	2	17	
Newport	26 (7.5)	22	1	3		3	3	3						3	1				4	
Other serovars	23 (6.6)	15	2	5	1	1	3	5	1	2	1	2	3	1			1	3	3	
Heidelberg	18 (5.2)	14	3	1		1	1	3	3	3	3	3	3	1						4
Paratyphi A and B	4 (1.2)				4															
Total	347 (100)	253	42	32	20		5	30	42	5	6	5	6	33	18		9	2	53	36
Saskatchewan																				
Enteritidis	135 (65.9)	125	7	3				2						2	2			8		3
Typhimurium	27 (13.2)	17	1	4	4	1	8	6	1	1	1	1	1	9	1		5	1	6	
Heidelberg	14 (6.8)	13	1			1	1							1						
4,[5],12:i:-	12 (5.9)	4	3	2	3		5	6						5	1				5	
Other serovars	9 (4.4)	6	1	1	1	1	1	2	1	1	1	1	1				1	1	2	
Newport	7 (3.4)	7					1	1						1	1		1	1		
Typhi	1 (0.5)																			
Total	205 (100)	172	12	11	9	1	2	16	17	2	2	2	2	19	5		6	1	11	16
Manitoba																				
Enteritidis	89 (57.4)	77	5	6	1		1	2						6	5			12		5
Typhimurium	16 (10.3)	14		1	1		2	2						2	1		2	1	1	2
Newport	14 (9.0)	12			2		2	2	2	2	2	2	2				2		2	
Other serovars	11 (7.1)	9	1	1	1	1								1			1	1	1	2
Heidelberg	8 (5.2)	2	5	1	1	1	1	6	6	6	6	6	1	1			1		1	
Typhi	8 (5.2)	6	2				2	2						2	2		2		8	
4,[5],12:i:-	5 (3.2)		2	3	1	5	5							5				1		3
Paratyphi A and B	4 (2.6)	3	1																1	
Total	155 (100)	117	17	9	11	1	3	13	19	8	8	8	8	19	9		8	2	24	15
Ontario																				
Enteritidis	287 (35.4)	215	60	3	9		9	10						11	2		1	2	68	7
Typhimurium	119 (14.7)	78	3	6	25	7	4	35	33	3	1			38	6	1	30	2	6	37
Heidelberg	102 (12.6)	63	28	7	4		11	9	31	27	27	26	27	9	3		1	2	5	
Newport	91 (11.2)	89	1	1			1	1												1
Other serovars	79 (9.8)	55	7	4	8	5	5	11	16	8	12	7	12	17	10	1	11	5	10	16
Typhi	63 (7.8)	8	36	2	17			16	16					18	17		17	6	55	2
4,[5],12:i:-	53 (6.5)	14	2	10	27		4	32	31	1	2	1	2	35	1	2	3	1	1	34
Paratyphi A and B	16 (2.0)	3	13															3	13	
Total	810 (100)	525	150	33	90	12	24	113	138	39	41	35	41	128	39	4	63	19	155	102

Antimicrobial abbreviations are defined in the Appendix.

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

Salmonella Paratyphi B does not include *S. Paratyphi B* var. L (+) tartrate (+), formerly called *S. Paratyphi* var.

Java. The biotype of *S. Paratyphi* B included here is tartrate (-) and associated with severe typhoid-like fever.

Salmonella Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness.

Table 4.1 Number of antimicrobial classes in resistance patterns of *Salmonella* from humans, 2015 (cont'd)

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial											
		0	1	2–3	4–5	6–7	Aminoglycosides	β-Lactams				Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines
		GEN	STR				AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL		TET	
Québec																				
Enteritidis	119 (32.3)	86	27	4	2		2	3	1	1	1	1	5	3		1	1	29	4	
Heidelberg	78 (21.2)	50	16	11	1		3	6	22	16	18	16	18	8	3		1	3	6	
Typhimurium	61 (16.6)	37	3	6	14	1	1	17	15	2	1	2	1	21	6	1	12	2	21	
Other serovars	45 (12.2)	27	4	11	3		6	15	13	10	10	9	10	16		12	2	7	17	
Newport	34 (9.2)	34																		
4,[5],12:i:-	19 (5.2)	8	1	1	9			9	9					9		1	2	10		
Typhi	9 (2.4)	3	4		2			2	2				2	2		2	1	5		
Paratyphi A and B	3 (0.8)	1	2														1	2		
Total	368 (100)	246	53	26	39	4	10	51	64	29	30	28	30	61	14	1	29	5	50	58
New Brunswick																				
Enteritidis	75 (53.6)	57	16	2				2	2					2		1	16	2		
Heidelberg	23 (16.4)	12	9	2			2	2	9	9	9	9	9	2						
Newport	14 (10.0)	14																		
Other serovars	10 (7.1)	9		1													1	1		
Typhimurium	10 (7.1)	7		1	2			3	3					3		3	2	3		
4,[5],12:i:-	5 (3.6)	3	1	1					1	1	1	1	1	1			1			
Paratyphi A and B	3 (2.1)	2	1						1	1	1	1	1							
Total	140 (100)	104	27	4	3	2	2	7	16	11	11	11	8			4	19	7		
Nova Scotia																				
Enteritidis	88 (75.2)	65	20	2	1			2	1					2	1	1	1	20	2	
Heidelberg	16 (13.7)	12	2	1	1		1	1	3	2	2	2	2	2	2	1		1		
Typhimurium	7 (6.0)	3	1	1	2			3	4	2	1	1	1	3		3	2	3		
4,[5],12:i:-	3 (2.6)	1	1	1				2	2				2	1			2		2	
Newport	3 (2.6)	2		1				1	1	1	1	1	1			1		1		
Total	117 (100)	82	24	4	5	2	1	9	11	5	4	4	4	10	4	2	5	22	9	
Prince Edward Island																				
Enteritidis	14 (93.3)	11	2	1										1	1		2	1		
Other serovars	1 (6.7)	1					1	1						1			2	1		
Total	15 (100)	11	2	2			1	1						2	1		2	1		
Newfoundland and Labrador																				
Enteritidis	34 (58.6)	26	7	1				1	1					1			8			
Heidelberg	7 (12.1)	7																		
Newport	7 (12.1)	7																		
4,[5],12:i:-	5 (8.6)	2		3				3	3				3				3			
Typhimurium	4 (6.9)	4																		
Other serovars	1 (1.7)	1																		
Total	58 (100)	47	7	4				4	4				4				8	3		
National																				
Enteritidis	1,188 (47.2)	961	164	42	21		1	23	42	1	1	1	1	41	30	1	5	3	207	37
Heidelberg	308 (12.2)	187	86	27	8		22	24	100	79	83	78	81	26	10	1	4	5		17
Typhimurium	291 (11.6)	193	9	22	53	14	6	78	70	9	4	6	4	89	15	2	61	3	15	80
Newport	229 (9.1)	216	1	3	9		4	10	11	5	5	5	5	9	1		5		12	
Other serovars	201 (8.0)	140	10	18	25	8	16	33	39	21	26	19	26	43	12	1	27	11	25	44
4,[5],12:i:-	140 (5.6)	42	16	23	59		6	74	72	2	3	2	3	78	4	2	4	1	10	82
Typhi	126 (5.0)	27	70	2	27			26	26					28	27		27	13	98	2
Paratyphi A and B	36 (1.4)	10	26						1	1	1	1	1				4	25		
Total	2,519 (100)	1,776	382	137	202	22	55	268	361	118	123	112	121	314	99	7	133	35	385	274

Antimicrobial abbreviations are defined in the Appendix.

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

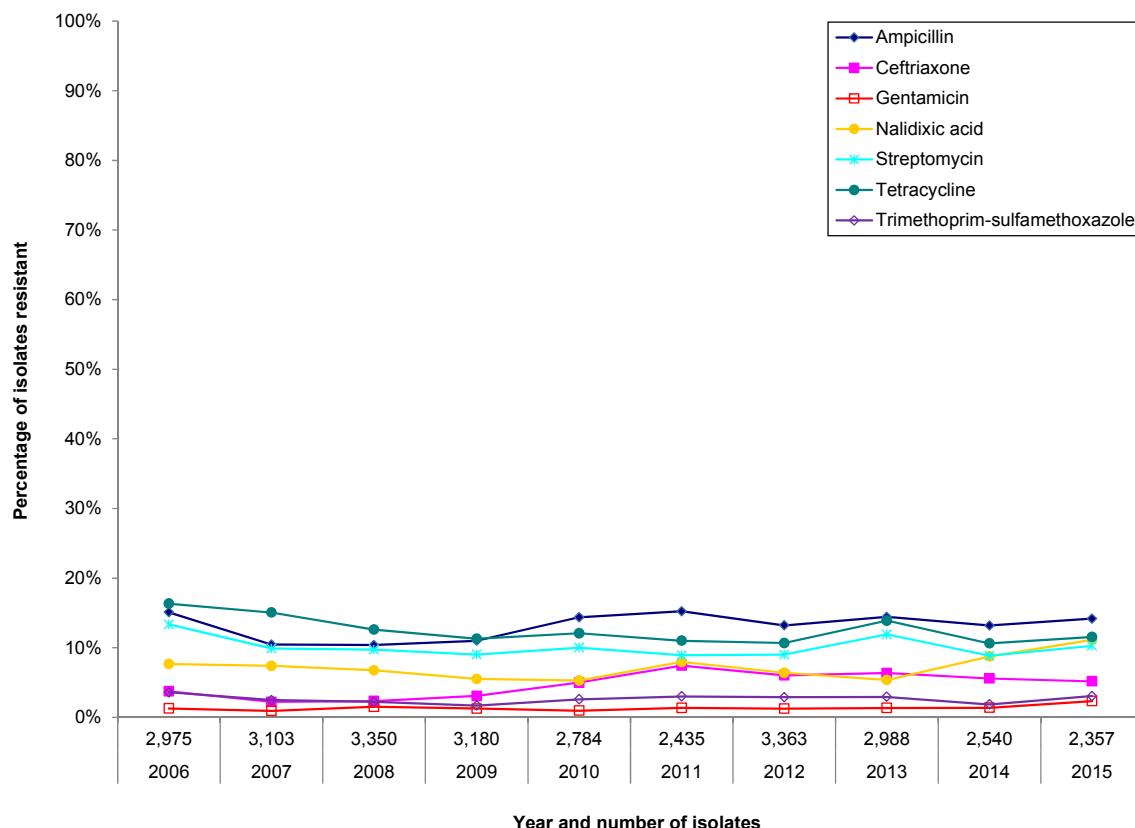
Salmonella Paratyphi B does not include *S. Paratyphi B* var. L (+) tartrate (+), formerly called *S. Paratyphi* var.

Java. The biotype of *S. Paratyphi B* included here is tartrate (-) and associated with severe typhoid-like fever.

Salmonella Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness.

TEMPORAL ANTIMICROBIAL RESISTANCE SUMMARY

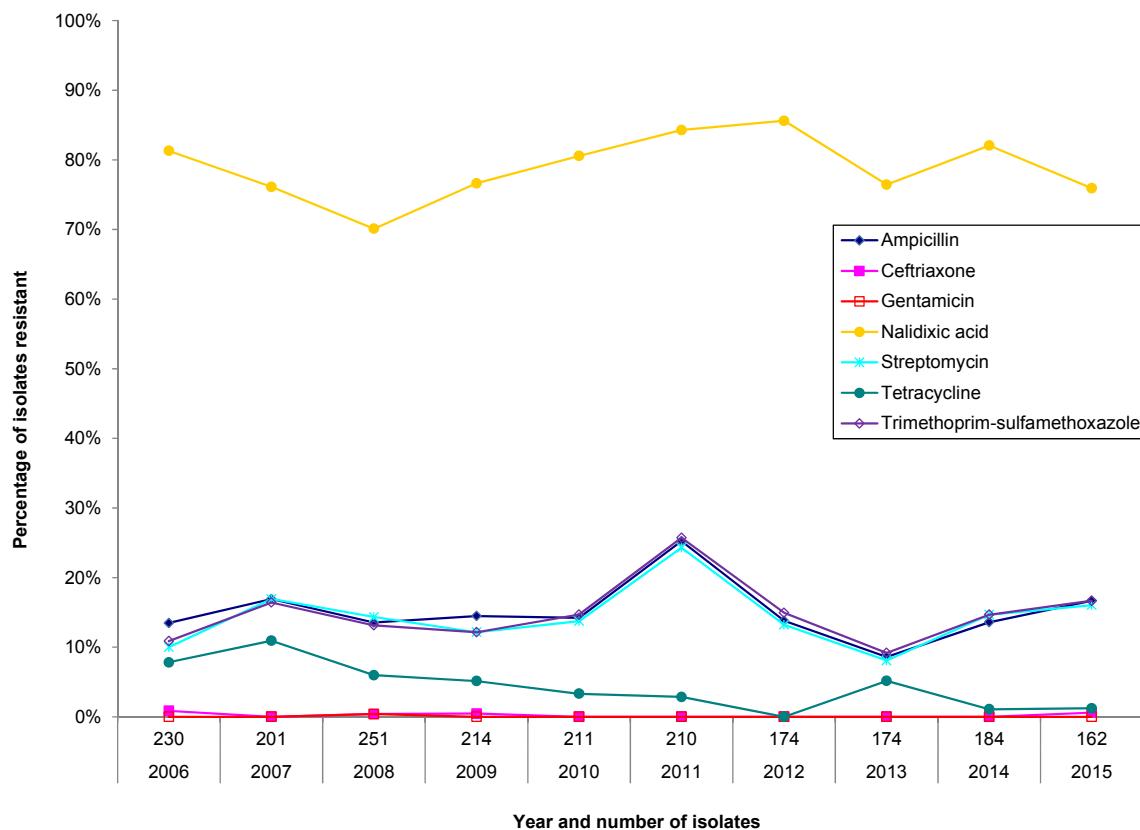
Figure 4. 2 Temporal variations in resistance of non-typhoidal *Salmonella* from humans, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	2,975	3,103	3,350	3,180	2,784	2,435	3,363	2,988	2,540	2,357
Antimicrobial										
Ampicillin	15%	10%	10%	11%	14%	15%	13%	14%	13%	14%
Ceftriaxone	4%	2%	2%	3%	5%	7%	6%	6%	6%	5%
Gentamicin	1%	1%	2%	1%	1%	1%	1%	1%	1%	2%
Nalidixic acid	8%	7%	7%	6%	5%	8%	6%	5%	9%	11%
Streptomycin	13%	10%	10%	9%	10%	9%	9%	12%	9%	10%
Tetracycline	16%	15%	13%	11%	12%	11%	11%	14%	11%	12%
Trimethoprim-sulfamethoxazole	4%	2%	2%	2%	3%	3%	3%	3%	2%	3%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

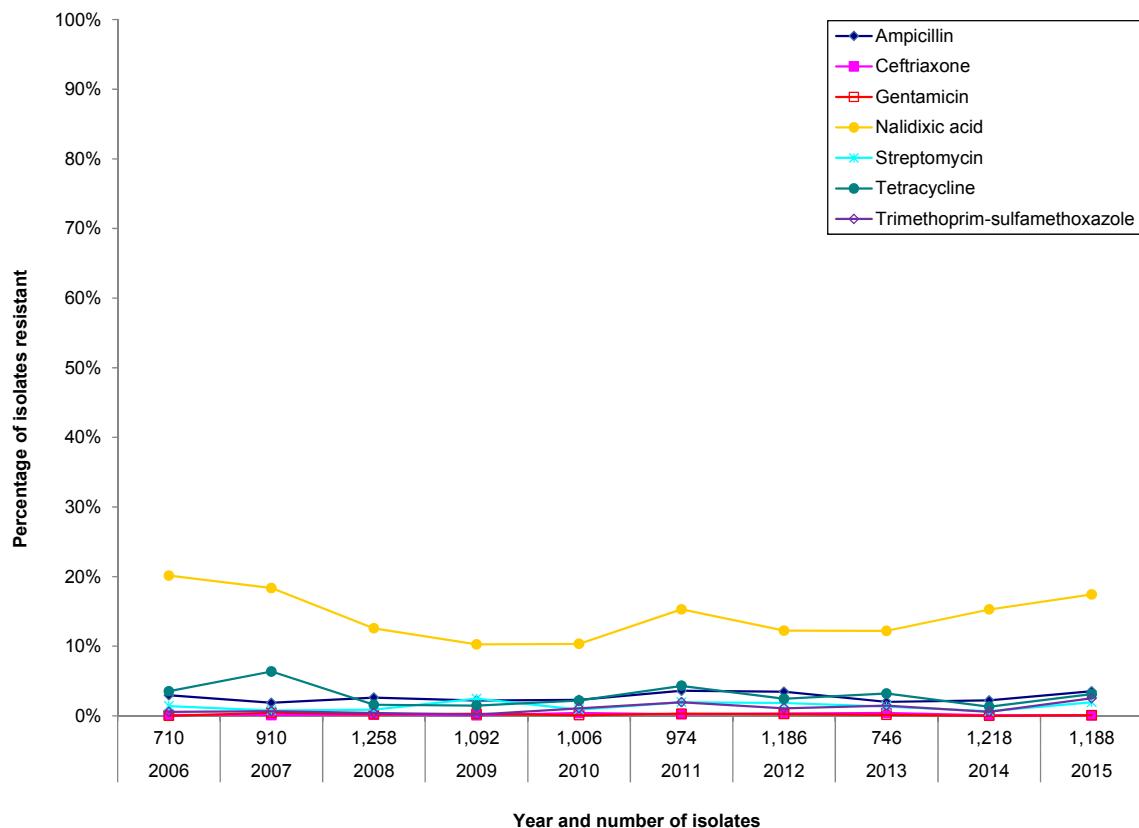
...working towards the preservation of effective antimicrobials for humans and animals...

Figure 4.3 Temporal variations in resistance of typhoidal *Salmonella* from humans, 2006–2015

Year Number of isolates	2006 230	2007 201	2008 251	2009 214	2010 211	2011 210	2012 174	2013 174	2014 184	2015 162
Antimicrobial										
Ampicillin	13%	17%	14%	14%	14%	25%	14%	9%	14%	17%
Ceftriaxone	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Nalidixic acid	81%	76%	70%	77%	81%	84%	86%	76%	82%	76%
Streptomycin	10%	17%	14%	12%	14%	24%	13%	8%	15%	16%
Tetracycline	8%	11%	6%	5%	3%	3%	0%	5%	1%	1%
Trimethoprim-sulfamethoxazole	11%	16%	13%	12%	15%	26%	15%	9%	15%	17%

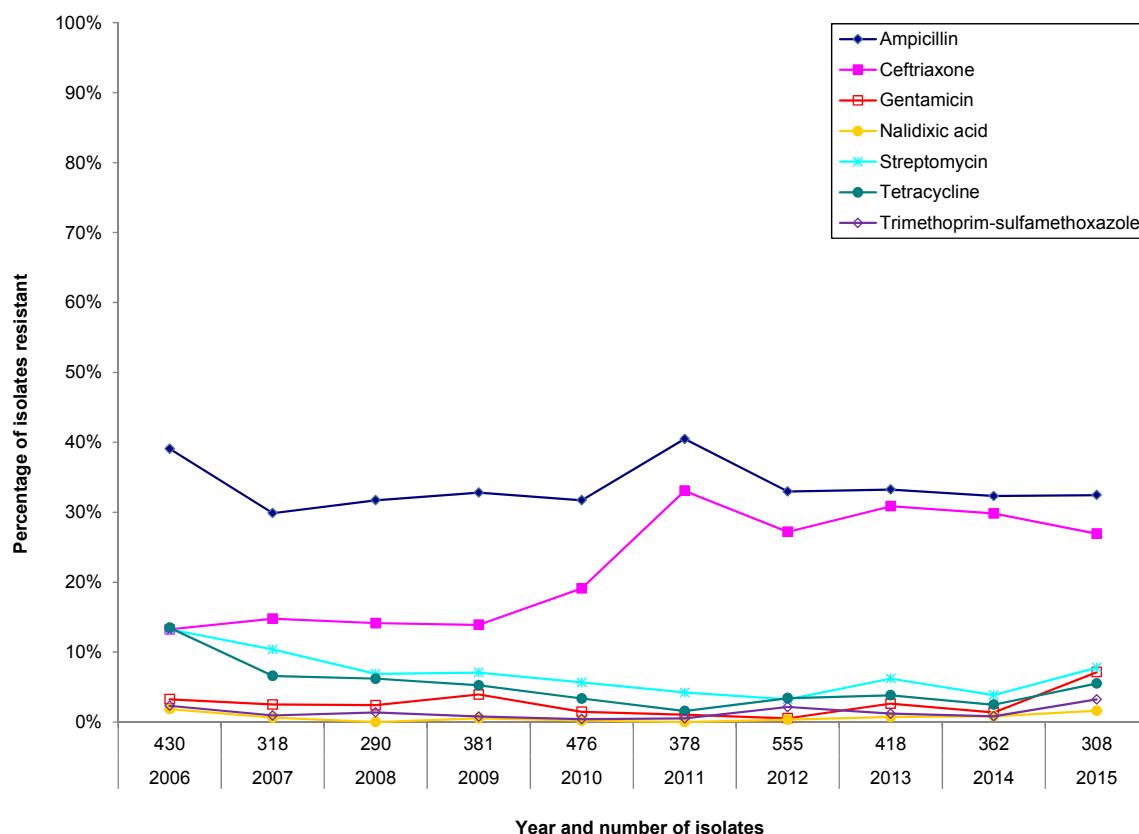
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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

Figure 4. 4 Temporal variations in resistance of *Salmonella* Enteritidis from humans, 2006–2015

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	710	910	1,258	1,092	1,006	974	1,186	746	1,218	1,188
Antimicrobial										
Ampicillin	3%	2%	3%	2%	2%	4%	3%	2%	2%	4%
Ceftriaxone	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Nalidixic acid	20%	18%	13%	10%	10%	15%	12%	12%	15%	17%
Streptomycin	1%	1%	1%	2%	1%	2%	2%	1%	1%	2%
Tetracycline	4%	6%	2%	1%	2%	4%	2%	3%	1%	3%
Trimethoprim-sulfamethoxazole	1%	1%	0%	0%	1%	2%	1%	1%	1%	3%

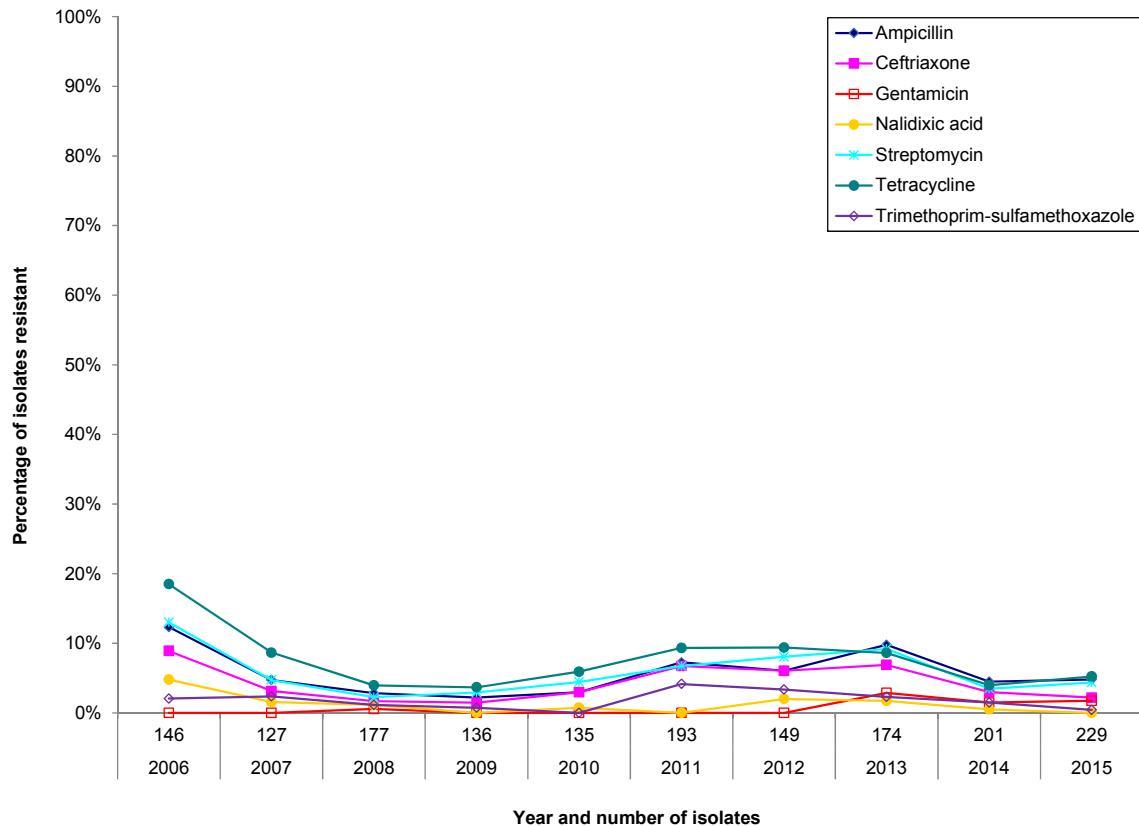
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 5 Temporal variations in resistance of *Salmonella* Heidelberg from humans, 2006–2015

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	430	318	290	381	476	378	555	418	362	308
Antimicrobial										
Ampicillin	39%	30%	32%	33%	32%	40%	33%	33%	32%	32%
Ceftriaxone	13%	15%	14%	14%	19%	33%	27%	31%	30%	27%
Gentamicin	3%	3%	2%	4%	1%	1%	1%	3%	1%	7%
Nalidixic acid	2%	1%	0%	1%	0%	0%	0%	1%	1%	2%
Streptomycin	13%	10%	7%	7%	6%	4%	3%	6%	4%	8%
Tetracycline	13%	7%	6%	5%	3%	2%	3%	4%	2%	6%
Trimethoprim-sulfamethoxazole	2%	1%	1%	1%	0%	1%	2%	1%	1%	3%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

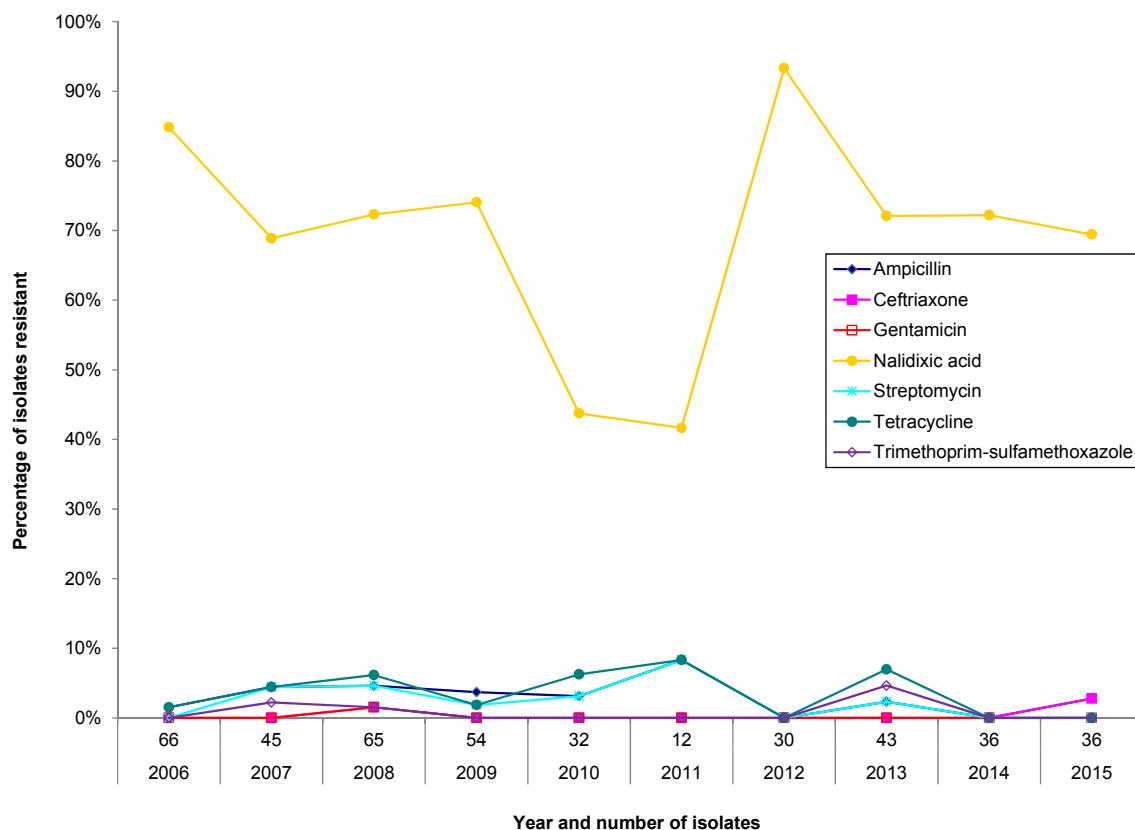
Figure 4. 6 Temporal variations in resistance of *Salmonella* Newport from humans, 2006–2015



Year Number of isolates	2006 146	2007 127	2008 177	2009 136	2010 135	2011 193	2012 149	2013 174	2014 201	2015 229
Antimicrobial										
Ampicillin	12%	5%	3%	2%	3%	7%	6%	10%	4%	5%
Ceftriaxone	9%	3%	2%	1%	3%	7%	6%	7%	3%	2%
Gentamicin	0%	0%	1%	0%	0%	0%	0%	3%	1%	2%
Nalidixic acid	5%	2%	1%	0%	1%	0%	2%	2%	0%	0%
Streptomycin	13%	5%	2%	3%	4%	7%	8%	9%	3%	4%
Tetracycline	18%	9%	4%	4%	6%	9%	9%	9%	4%	5%
Trimethoprim-sulfamethoxazole	2%	2%	1%	1%	0%	4%	3%	2%	1%	0%

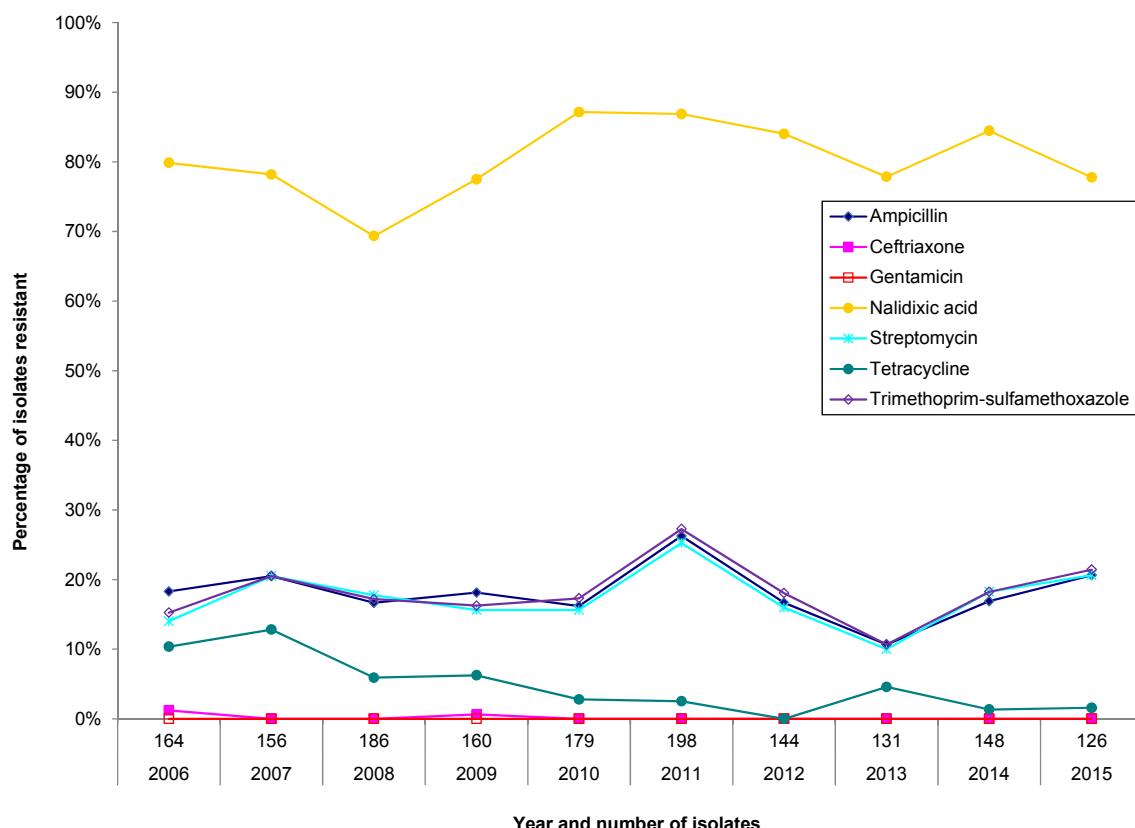
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 7 Temporal variations in resistance of *Salmonella Paratyphi A* and *B* from humans, 2006–2015



Year Number of isolates	2006 66	2007 45	2008 65	2009 54	2010 32	2011 12	2012 30	2013 43	2014 36	2015 36
Antimicrobial										
Ampicillin	2%	4%	5%	4%	3%	8%	0%	2%	0%	3%
Ceftriaxone	0%	0%	2%	0%	0%	0%	0%	0%	0%	3%
Gentamicin	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%
Nalidixic acid	85%	69%	72%	74%	44%	42%	93%	72%	72%	69%
Streptomycin	0%	4%	5%	2%	3%	8%	0%	2%	0%	0%
Tetracycline	2%	4%	6%	2%	6%	8%	0%	7%	0%	0%
Trimethoprim-sulfamethoxazole	0%	2%	2%	0%	0%	0%	0%	5%	0%	0%

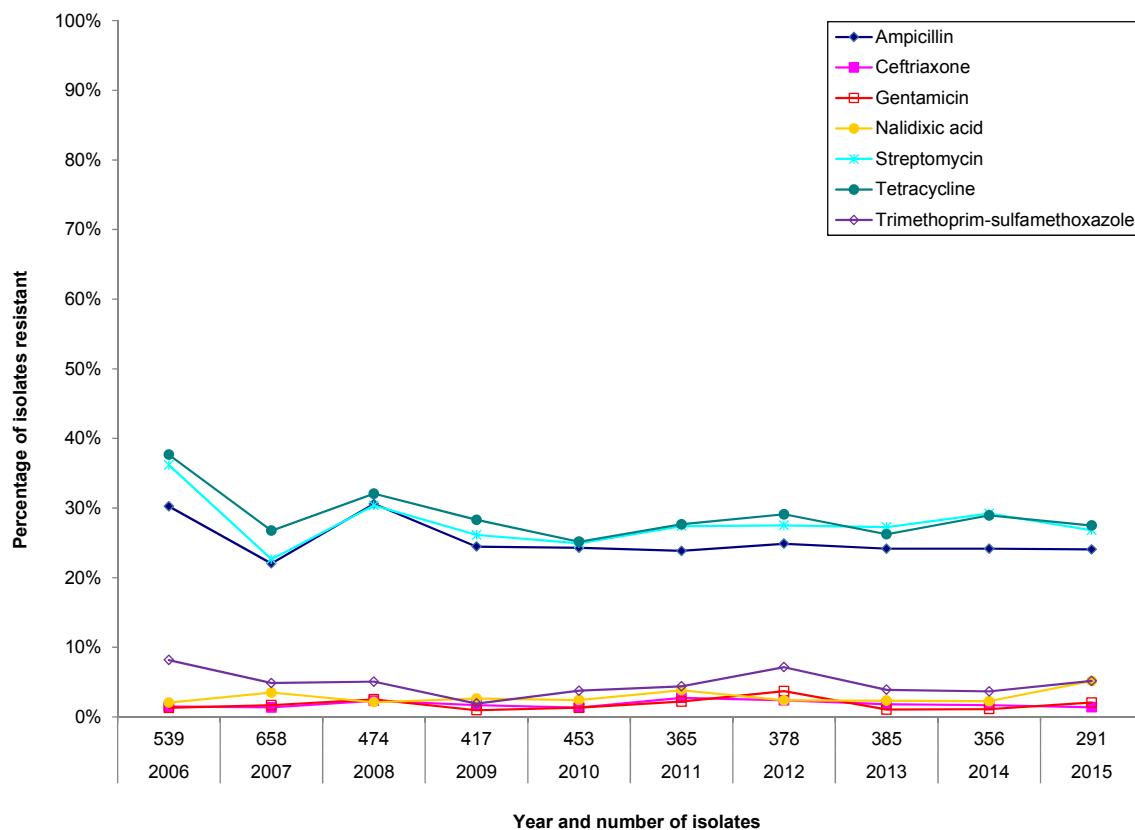
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4.8 Temporal variations in resistance of *Salmonella Typhi* from humans, 2006–2015

Year Number of isolates	2006 164	2007 156	2008 186	2009 160	2010 179	2011 198	2012 144	2013 131	2014 148	2015 126
Antimicrobial										
Ampicillin	18%	21%	17%	18%	16%	26%	17%	11%	17%	21%
Ceftriaxone	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Nalidixic acid	80%	78%	69%	78%	87%	87%	84%	78%	84%	78%
Streptomycin	14%	21%	18%	16%	16%	25%	16%	10%	18%	21%
Tetracycline	10%	13%	6%	6%	3%	3%	0%	5%	1%	2%
Trimethoprim-sulfamethoxazole	15%	21%	17%	16%	17%	27%	18%	11%	18%	21%

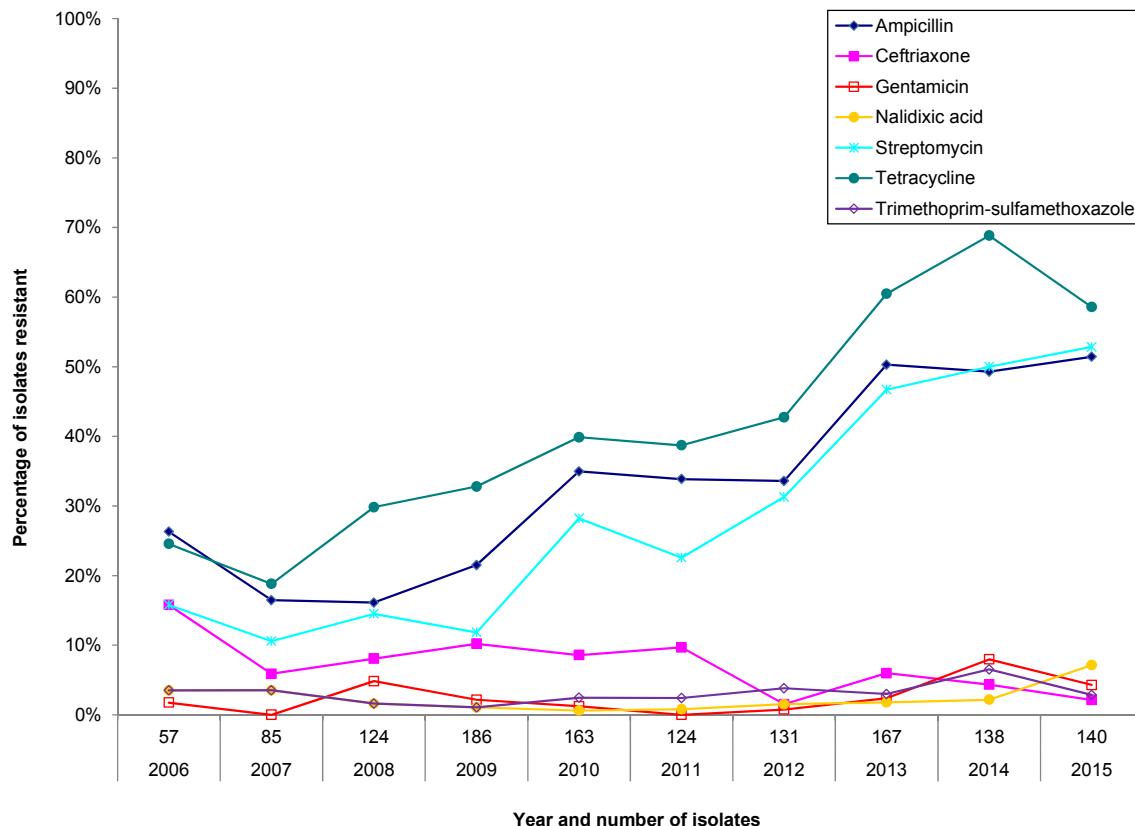
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4.9 Temporal variations in resistance of *Salmonella* Typhimurium from humans, 2006–2015



Year Number of isolates	2006 539	2007 658	2008 474	2009 417	2010 453	2011 365	2012 378	2013 385	2014 356	2015 291
Antimicrobial										
Ampicillin	30%	22%	31%	24%	24%	24%	25%	24%	24%	24%
Ceftriaxone	1%	1%	2%	2%	1%	3%	2%	2%	2%	1%
Gentamicin	1%	2%	3%	1%	1%	2%	4%	1%	1%	2%
Nalidixic acid	2%	3%	2%	3%	2%	4%	2%	2%	2%	5%
Streptomycin	36%	23%	30%	26%	25%	27%	28%	27%	29%	27%
Tetracycline	38%	27%	32%	28%	25%	28%	29%	26%	29%	27%
Trimethoprim-sulfamethoxazole	8%	5%	5%	2%	4%	4%	7%	4%	4%	5%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 10 Temporal variations in resistance of *Salmonella* 4,[5],12:i:- from humans, 2006–2015

Year Number of isolates	2006 57	2007 85	2008 124	2009 186	2010 163	2011 124	2012 131	2013 167	2014 138	2015 140
Antimicrobial										
Ampicillin	26%	16%	16%	22%	35%	34%	34%	50%	49%	51%
Ceftriaxone	16%	6%	8%	10%	9%	10%	2%	6%	4%	2%
Gentamicin	2%	0%	5%	2%	1%	0%	1%	2%	8%	4%
Nalidixic acid	4%	4%	2%	1%	1%	1%	2%	2%	2%	7%
Streptomycin	16%	11%	15%	12%	28%	23%	31%	47%	50%	53%
Tetracycline	25%	19%	30%	33%	40%	39%	43%	60%	69%	59%
Trimethoprim-sulfamethoxazole	4%	4%	2%	1%	2%	2%	4%	3%	7%	3%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

RETAIL MEAT SURVEILLANCE

KEY FINDINGS³¹

A summary of *Retail Meat Surveillance* recovery rates are presented in Table 4. 10.

BEEF

ESCHERICHIA COLI (n = 263)

As in previous years, overall resistance levels of Category I β -lactams (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) remained low in beef *E. coli* isolates in 2015. In fact, the only province/region where Category I β -lactam resistance was observed in 2015 was British Columbia (2%, 1/45) (Table 4. 2). Similar to 2014, no *E. coli* from beef were resistant to all 7 classes of antimicrobials tested (Table 4. 2). No ciprofloxacin resistance was observed among *E. coli* isolated from ground beef.

CHICKEN

SALMONELLA (n = 281)

When data from all provinces/regions were combined, the top 3 chicken *Salmonella* serovars were Enteritidis, Kentucky, and Heidelberg as in previous years although the ranking of the second and third most common serovars does vary from year to year. Regional differences in serovar distribution were observed in 2015 with Enteritidis being the most common serovar in the western Canadian provinces/regions of British Columbia (70%, 48/69) and the Prairies (51%, 39/77) unlike Ontario and Québec where the most common serovar was Kentucky (42%, 11/26 and 45%, 49/109, respectively) (Table 4. 3). In 2014, Heidelberg was the most frequent serovar in both Ontario and Québec. In general and similar to most recent past years; no Enteritidis recovered in Ontario (0%, 0/26) and Québec (6%, 6/109).

Only 1% (1/93) of Enteritidis isolates was resistant to 1 or more antimicrobials tested. (1/93). One Enteritidis isolate from the Prairies was resistant to ampicillin only; this is the first isolate of Enteritidis from retail chicken to-date that has demonstrated resistance (any drug or class). In 2015, no ciprofloxacin resistance was observed (Table 4. 3).

In 2015, when data from all provinces/regions were combined, resistance levels of Category I β -lactams (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) (13%, 36/281) were lower compared to levels in 2014 (21%, 72/343) (Figure 4. 12). Resistance to ceftriaxone was significantly lower (14%, 10/69) in 2015 than 2011 (38%, 24/64) in British Columbia (Figure 4. 12). Resistance to ceftriaxone was significantly lower (9%, 7/77) in 2015 than 2011 (24%,

³¹ For 2015, due to limited sampling technician availability, only a partial year's worth of retail sampling was conducted in Ontario. Sampling target and isolate yields were therefore not achieved in Ontario. All 2015 Ontario retail data should be interpreted with caution. Additionally in 2015, retail sampling activities in the Atlantic region were suspended due to budgetary constraints.

7/29) in the Prairies (Figure 4. 12). Resistance to ceftriaxone was significantly lower (12%, 3/26) in 2015 than 2004 (45%, 25/54) in Ontario (Figure 4. 12). Resistance to ceftriaxone was significantly lower (15%, 16/109) in 2015 than 2014 (27%, 25/92), 2011 (29%, 29/100) and 2004 (37%, 22/60) in Québec (Figure 4. 12).

ESCHERICHIA COLI (n = 365)

In general, resistance levels of Category I β -lactams (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) in 2015 were comparable (16%, 58/365; 17%, 61/365; and 15%, 56/365, respectively) to those in 2014 (19% 119/619, 19% 120/619, and 18% 110/619, respectively) when data from all provinces/regions were combined (Figure 4. 13). Resistance to ceftriaxone was significantly lower in 2015 (12%, 8/69) than 2011 (29%, 40/137), 2006³² (28%, 42/152) and 2004 (24%, 36/150) in Ontario (Figure 4. 13). Resistance to ceftriaxone was significantly lower in 2015 (12%, 15/127) than 2011 (23%, 31/134) and 2004 (40%, 63/158) in Québec (Figure 4. 13). Resistance to gentamicin was significantly higher in 2015 (22%, 15/69) than 2011 (11%, 15/137) in Ontario (Figure 4. 13).

No ciprofloxacin resistance was observed among *E. coli* isolated from chicken. One isolate from Québec was resistant to 6 of 7 antimicrobial classes with the following pattern ACSSuT-A2C-CRO-GEN-NAL.

CAMPYLOBACTER (n = 199)

Ciprofloxacin resistance remained highest in British Columbia in 2015 (41%, 19/46) when data from all provinces/regions were combined. In fact, ciprofloxacin resistance was significantly higher in 2015 than 2014 (21%, 9/43) and 2011 (13%, 9/71) (Figure 4. 14). No other increases or decreases in ciprofloxacin resistance were significant in 2015. Unlike previous years where low levels of telithromycin resistance were observed when data from all provinces/regions were combined, in 2015 resistance to telithromycin was only observed in the Prairies (6%, 4/65) (Table 4. 5 and Figure 4. 14).

PORK

ESCHERICHIA COLI (n = 179)

In 2015, Category I β -lactam ceftriaxone, and ceftiofur resistance levels in pork *E. coli* isolates remained relatively stable (2%, 3/179), compared to the previous 5 years (Figure 4. 15). One isolate from Ontario (1%, 1/64) was resistant to azithromycin (Table 4. 6).

³² Additional temporal analyses for ampicillin and ceftiofur/ceftriaxone were conducted for *Salmonella* isolates from Ontario and Québec. These 2 antimicrobials, provinces, and years (2004 and 2006) were selected due to a change in ceftiofur use practices by Québec chicken hatcheries in early 2005 and in 2007 (start and end of the voluntary period of withdrawal). Data for 2004 and 2006 are not shown in figures and tables.

TURKEY

SALMONELLA (n = 178)

The distribution of *Salmonella* serovars varied greatly by province/region for retail surveillance of ground turkey in 2015 (Table 4. 7). No ciprofloxacin or nalidixic acid resistance was observed (Table 4. 7). Category I β-lactam (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) resistance levels in turkey *Salmonella* isolates were variable ranging from a low of 0% in British Columbia (0/38) to a high of 13% (7/52) in Québec (Table 4. 7).

ESCHERICHIA COLI (n = 359)

Except for British Columbia where no ciprofloxacin resistance was observed, ciprofloxacin resistance in turkey *E. coli* isolates was observed in all other provinces/regions: Prairies (1%, 1/106), Ontario (3%, 2/70) and Québec (1%, 1/116) (Table 4. 8). This is the second straight year where ciprofloxacin resistance has been seen in turkey *E. coli* isolates to-date; no resistance was observed before 2014. In 2015, resistance levels of Category I β-lactams (amoxicillin-clavulanic acid, ceftriaxone, and ceftiofur) in turkey *E. coli* isolates ranged from 2% in Québec (2/116) to 7% (5/67) in British Columbia (Table 4. 8). Resistance to ceftriaxone was significantly lower in Québec in 2015 (3%, 3/116) than 2012 (11%, 19/170) (Figure 4. 17). Resistance to gentamicin was significantly higher in 2015 in British Columbia (18%, 12/65) and Québec (18%, 21/116) than 2012 (7%, 7/101; 9%, 16/170 respectively) (Figure 4. 17). One isolate from each of the Prairies, Ontario and Québec was resistant to 6 antimicrobial classes with the following patterns respectively: ACSSuT-CIP-GEN-NAL-SXT, AMP-CHL-CIP-GEN-NAL-SSS-TET and ACSSuT-NAL.

CAMPYLOBACTER (n = 52)

With the exception of Ontario (0%, 0/8), ciprofloxacin resistance was observed across all other provinces/regions sampled as follows: 25% (6/24) of isolates from British Columbia, 18% (2/11) of isolates from the Prairies and 11% (1/9) of isolates from Québec (Table 4. 9). Resistance to telithromycin was lower in 2015 (2%, 1/52) compared to 2014 (10%, 7/73) when data from all provinces/regions were combined; in fact only one isolate from the Prairies was resistant to telithromycin (Table 4. 9).

MULTICLASS RESISTANCE

Table 4. 2 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from beef, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides		β-Lactams				Folate pathway inhibitors		Macrolides		Phenicols		Quinolones		Tetracyclines				
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
British Columbia	45 (17.1)	32	9	4			1		4	1	1	1	1	1				1	10	
Prairies	86 (32.7)	76	5	3	2		1		5	1				3	1		2	2	7	
Ontario	53 (20.2)	33	6	12	2				7	4				12	3		2	1	18	
Québec	79 (30.0)	57	8	11	3				7	4				12	3		2	1	21	
National	263 (100)	198	28	30	7		1	20	13	1	1	1	1	28	7		6	5	56	

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 3 Number of antimicrobial classes in resistance patterns of *Salmonella* from chicken, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern	Number of isolates resistant by antimicrobial class and antimicrobial																		
			Aminoglycosides			β-Lactams			Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines				
			0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
British Columbia																					
Enteritidis	48 (69.6)	48																			
Kentucky	11 (15.9)	1	7	3				10		6	6	6	3	6				3	10		
Thompson	4 (5.8)	4																			
Heidelberg	2 (2.9)	2								2	2	2	2	2	2						
8:20:-:26	2 (2.9)		2					2		2	2	2	1	2					2		
Less common serovars	2 (2.9)	1	1																1		
Total	69 (100)	54	3	9	3			12	10	10	10	6	10				3	13			
Prairies																					
Enteritidis	39 (50.6)	38	1								1										
Infantis	9 (11.7)	7	2							2	2	2	2	2	2						
Kentucky	8 (10.4)	1	6	1				7		2	2	2	2	2	2			1	7		
Heidelberg	4 (5.2)	2	2							2	2	2	2	2	2						
Schwarzengrund	3 (3.9)	2	1							1	1	1	1	1	1						
Hadar	2 (2.6)	1	1					2		1									1		
4:[5],12:i:-	2 (2.6)	2																			
Mbandaka	2 (2.6)		2					1							2	1			2		
Thompson	2 (2.6)	2																			
Typhimurium	2 (2.6)	2																			
Less common serovars	4 (5.2)	2	1	1				2		1	1										
Total	77 (100)	58	8	10	1			2	11	10	7	7	7	7	2	1	1	10			
Ontario																					
Kentucky	11 (42.3)		11							11									11		
Heidelberg	6 (23.1)	4	1	1				1		2	2	2	2	2	2						
Braenderup	1 (3.8)	1																			
Hadar	1 (3.8)	1																			
6,7:-1,5	1 (3.8)	1																			
Infantis	1 (3.8)	1								1	1	1	1	1	1						
Livingstone	1 (3.8)	1																	1		
Mbandaka	1 (3.8)	1																			
Schwarzengrund	1 (3.8)	1																			
Thompson	1 (3.8)	1																			
Typhimurium	1 (3.8)	1																	1		
Total	26 (100)	10	3	13				12	3	3	3	3	3	3	1			13			
Québec																					
Kentucky	49 (45.0)	2	2	45				45		5	5	5	5	5	5				47		
Heidelberg	29 (26.6)	17	10	2				2		11	10	10	10	10	10	1					
Enteritidis	6 (5.5)	6																			
Thompson	6 (5.5)	6																			
Hadar	4 (3.7)		4					4											4		
Infantis	3 (2.8)	3																			
Typhimurium	3 (2.8)		3												3	1			3		
Less common serovars	9 (8.3)	5	4		1	3	1	1	1	1	1	1	1	2	1				4		
Total	109 (100)	39	12	58				1	54	17	16	16	16	16	6	2		1	58		
National																					
Enteritidis	93 (33.1)	92	1							1											
Kentucky	79 (28.1)	4	2	69	4			73		13	13	13	10	13				4	75		
Heidelberg	41 (14.6)	23	15	3				3		17	16	16	16	16	16	1					
Infantis	13 (4.6)	10	3						3	3	3	3	3	3							
Thompson	13 (4.6)	13																			
Hadar	7 (2.5)	1	1	5				6		1									5		
Typhimurium	7 (2.5)	2	1	4				3		5	4	4	3	4	4	1			5		
Less common serovars	28 (10.0)	16	3	9		3	7	5	4	4	3	4	4	2				9			
Total	281 (100)	161	26	90	4			3	89	40	36	36	32	36	9	3		1	4	94	

Antimicrobial abbreviations are defined in the Appendix.

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

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 4 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from chicken, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial															
								Aminoglycosides			β-Lactams			Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines	
		0	1	2–3	4–5	6–7		GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET		
British Columbia	62 (17.0)	8	14	20	20		7	33	42	19	19	19	16	29	9		6	1		36			
Prairies	107 (29.3)	40	20	28	19		17	28	40	17	19	17	18	39	8		4	5		50			
Ontario	69 (18.9)	23	12	27	7		15	20	22	7	8	7	7	22	6		1	1		34			
Québec	127 (34.8)	26	17	55	28	1	35	58	48	15	15	15	15	70	33		11	4		73			
National	365 (100)	97	63	130	74	1	74	139	152	58	61	58	56	160	56		22	11		193			

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 5 Number of antimicrobial classes in resistance patterns of *Campylobacter* from chicken, 2015

Province or region / species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial													
		0	1	2–3	4–5	6–7		GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET					
British Columbia																					
<i>Campylobacter jejuni</i>	39 (84.8)	16	8	15													1	1	16	16	21
<i>Campylobacter coli</i>	7 (15.2)	4	2	1													3	3	3	3	1
Total	46 (100)	20	10	16													1	1	19	19	22
Prairies																					
<i>Campylobacter jejuni</i>	60 (92.3)	35	16	7	2				3	2	3	3					6	6	6	6	25
<i>Campylobacter coli</i>	5 (7.7)	4		1				1	1	1	1	1					1	1	1	1	1
Total	65 (100)	39	16	7	3				4	3	4	4					6	6	6	6	26
Ontario																					
<i>Campylobacter jejuni</i>	32 (82.1)	16	11	5													5	5	5	5	16
<i>Campylobacter coli</i>	7 (17.9)	5		2													1	1	1	1	2
Total	39 (100)	21	11	7													1	1	6	6	18
Québec																					
<i>Campylobacter jejuni</i>	46 (93.9)	24	18	4													1	4	4	4	21
<i>Campylobacter coli</i>	3 (6.1)	1	2														1	1	1	1	1
Total	49 (100)	25	20	4													1	1	1	1	22
National																					
<i>Campylobacter jejuni</i>	177 (88.9)	91	53	31	2				3	3	8	8					27	27	27	27	83
<i>Campylobacter coli</i>	22 (11.1)	14	4	3	1				1	1	2	2	2				5	5	5	5	5
Total	199 (100)	105	57	34	3				4	4	10	10					32	32	32	32	88

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 6 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from pork, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial													
								Aminoglycosides		β-Lactams				Folate pathway inhibitors		Macrolides		Phenicols		Quinolones	
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET	
British Columbia	29 (16.2)	16	2	8	3		8		6	1	1	1	1	7	3		1			12	
Prairies	50 (27.9)	27	10	9	4		8		12	1	1	1	1	6	1			4		19	
Ontario	64 (35.8)	17	13	25	9		22		23	2	1	2	1	18	10	1		6		44	
Québec	36 (20.1)	17	5	13	1		6		6					12	5			3		17	
National	179 (100)	77	30	55	17		44		47	4	3	4	3	43	19	1	14			92	

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel.

As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 7 Number of antimicrobial classes in resistance patterns of *Salmonella* from turkey, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial															
		0		2–3		4–5			6–7		Aminoglycosides			β-Lactams			Folate pathway inhibitors		Macrolides		Phenolics		Quinolones	
		GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET									
British Columbia																								
Enteritidis	20 (52.6)	20																						
Reading	6 (15.8)	5	1																		1			
Hadar	5 (13.2)		5																		5			
4.[5].12:i:-	2 (5.3)	1	1																					
Infantis	1 (2.6)	1																						
Liverpool	1 (2.6)	1																						
Muenchen	1 (2.6)	1																						
Senftenberg	1 (2.6)		1																		1			
Typhimurium	1 (2.6)		1																		1			
Total	38 (100)	29	8	1		2	8	5												1	7			
Prairies																								
Reading	15 (29.4)	15																						
Hadar	12 (23.5)		12																		12			
Enteritidis	4 (7.8)	3	1																					
Schwarzengrund	4 (7.8)	3	1																		1			
Agona	2 (3.9)	2																						
Albany	2 (3.9)		2																					
Heidelberg	2 (3.9)	2																						
4.[8].12:i:-	2 (3.9)	1	1																		1			
Livingstone	2 (3.9)		2																		2			
Senftenberg	2 (3.9)		2																		2			
Less common serovars	4 (7.8)	2	1	1																	2			
Total	51 (100)	28	3	15	5		5	18	16	1	2	2	6						2	20				
Ontario																								
Heidelberg	16 (43.2)	7	9																					
Schwarzengrund	5 (13.5)	5																			5			
Agona	4 (10.8)	3	1																		1			
Albany	2 (5.4)		2																		1			
Muenchen	2 (5.4)	1	1																					
Brandenburg	1 (2.7)		1																					
Enteritidis	1 (2.7)	1																						
Kiambu	1 (2.7)	1																						
Livingstone	1 (2.7)		1																		1			
Montevideo	1 (2.7)	1																						
Saintpaul	1 (2.7)	1																						
Typhimurium	1 (2.7)		1																		1			
Worthington	1 (2.7)		1																		1			
Total	37 (100)	14	5	18		13	15	2	2	2	2	6							15	10				
Québec																								
Heidelberg	23 (44.2)	7	8	8																				
Muenchen	11 (21.2)	8	3																		3			
Agona	6 (11.5)	3	3																		3			
Brandenburg	2 (3.8)	2																						
Enteritidis	2 (3.8)	2																						
Less common serovars	8 (15.4)	4	2	2																	1			
Total	52 (100)	26	10	16		14	15	8	7	7	6	7	15							7				
National																								
Heidelberg	41 (23)	16	8	17																				
Enteritidis	27 (15.2)	26	1																					
Reading	21 (11.8)	20	1																		1			
Hadar	17 (9.6)		17																		17			
Muenchen	14 (7.9)	10	1	3																	3			
Agona	12 (6.7)	8	4																		4			
Schwarzengrund	10 (5.6)	3	6	1																	7			
Albany	4 (2.2)		4																		1			
4.[5].12:i:-	4 (2.2)	2	1	1																	1			
Senftenberg	4 (2.2)		1	3																	3			
Less common serovars	24 (13.5)	12	8	3	1																7			
Total	178 (100)	97	18	57	6		34	56	31	10	11	8	11	40					3	44				

Antimicrobial abbreviations are defined in the Appendix.

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

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel.

As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 8 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from turkey, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial											
		Aminoglycosides		β-Lactams					Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines			
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
British Columbia	67 (18.7)	26	6	27	8		12	29	22	5	5	5	5	22	2		5			34
Prairies	106 (29.5)	37	20	33	15	1	21	36	30	3	3	3	3	31	12		4	1	2	58
Ontario	70 (19.5)	17	12	32	8	1	12	21	25	3	3	3	3	27	7		5	2	3	48
Québec	116 (32.3)	24	27	50	14	1	21	36	34	4	3	4	2	47	17	1	6	1	4	81
National	359 (100)	104	65	142	45	3	66	122	111	15	14	15	13	127	38	1	20	4	9	221

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Table 4. 9 Number of antimicrobial classes in resistance patterns of *Campylobacter* from turkey, 2015

Province or region / species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides		Ketolides		Lincosamides		Macrolides		Phenolics		Quinolones		Tetracyclines							
		0	1	2–3	4–5	6–7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET						
British Columbia																					
<i>Campylobacter jejuni</i>	20 (83.3)	11	6	3													3	3		9	
<i>Campylobacter coli</i>	4 (16.7)		1	3													3	3		4	
Total	24 (100)	11	7	6													6	6		13	
Prairies																					
<i>Campylobacter jejuni</i>	10 (90.9)	5	4	1													1	1		5	
<i>Campylobacter coli</i>	1 (9.1)			1													1	1		1	
Total	11 (100)	5	4	1	1				1	1	1	1	1	1	1		2	2		6	
Ontario																					
<i>Campylobacter jejuni</i>	6 (75.0)	2	4																		4
<i>Campylobacter coli</i>	2 (25.0)		1	1													1	1		2	
Total	8 (100)	2	5	1													1	1		6	
Québec																					
<i>Campylobacter jejuni</i>	6 (66.7)	3	2	1													1	1		3	
<i>Campylobacter coli</i>	3 (33.3)	2		1													1	1		1	
Total	9 (100)	5	2	2													1	1		4	
National																					
<i>Campylobacter jejuni</i>	42 (80.8)	21	16	5													5	5		21	
<i>Campylobacter coli</i>	10 (19.2)	2	2	5	1												4	4		8	
Total	52 (100)	23	18	10	1				1	1	3	3	3	3	3		9	9		29	

Antimicrobial abbreviations are defined in the Appendix.

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

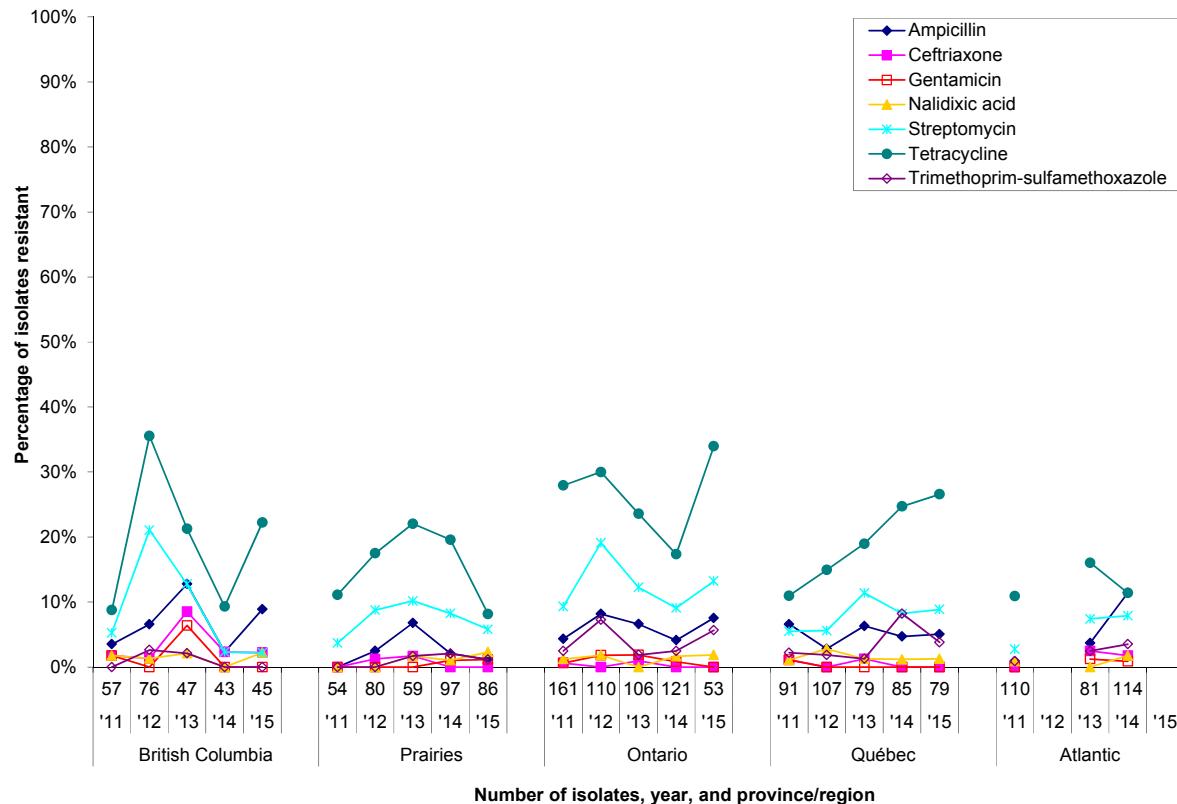
Campylobacter spp. include unidentified species, some of which may be intrinsically resistant to nalidixic acid.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

TEMPORAL ANTIMICROBIAL RESISTANCE SUMMARY

Figure 4. 11 Temporal variations in resistance of *Escherichia coli* isolates from beef, 2011–2015



Province / region	British Columbia					Prairies					Ontario					Québec					Atlantic						
	Year	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	
		Number of isolates	57	76	47	43	45	54	80	59	97	86	161	110	106	121	53	91	107	79	85	79	110	112	81	114	
Antimicrobial																											
Ampicillin		4%	7%	13%	2%	9%		0%	3%	7%	2%	1%		4%	8%	7%	4%	8%		7%	3%	6%	5%	5%		1%	
Ceftriaxone		2%	1%	9%	2%	2%		0%	1%	2%	0%	0%		1%	0%	1%	0%	0%		1%	0%	1%	0%	0%		0%	
Gentamicin		2%	0%	6%	0%	0%		0%	0%	0%	1%	1%		1%	2%	2%	1%	0%		1%	0%	0%	0%	0%		0%	
Nalidixic acid		2%	1%	2%	0%	2%		0%	0%	2%	1%	2%		0%	0%	2%	2%	2%		1%	3%	1%	1%	1%		1%	
Streptomycin		5%	21%	13%	2%	2%		4%	9%	10%	8%	6%		9%	19%	12%	9%	13%		5%	6%	11%	8%	9%		3%	
Tetracycline		9%	36%	21%	9%	22%		11%	18%	22%	20%	8%		28%	30%	24%	17%	34%		11%	15%	19%	25%	27%		11%	
Trimethoprim-sulfamethoxazole		0%	3%	2%	0%	0%		0%	0%	2%	2%	1%		2%	7%	2%	2%	6%		2%	2%	1%	8%	4%		1%	

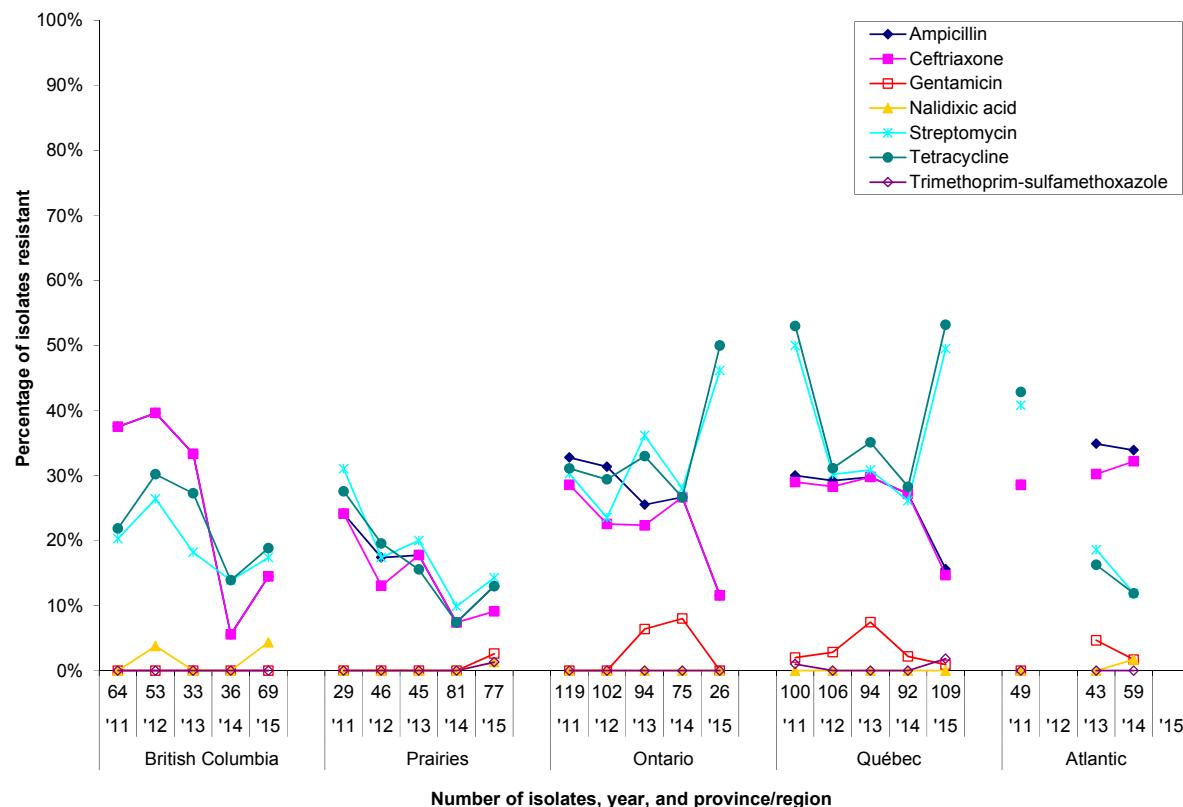
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

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For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

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

Figure 4. 12 Temporal variations in resistance of *Salmonella* isolates from chicken, 2011–2015

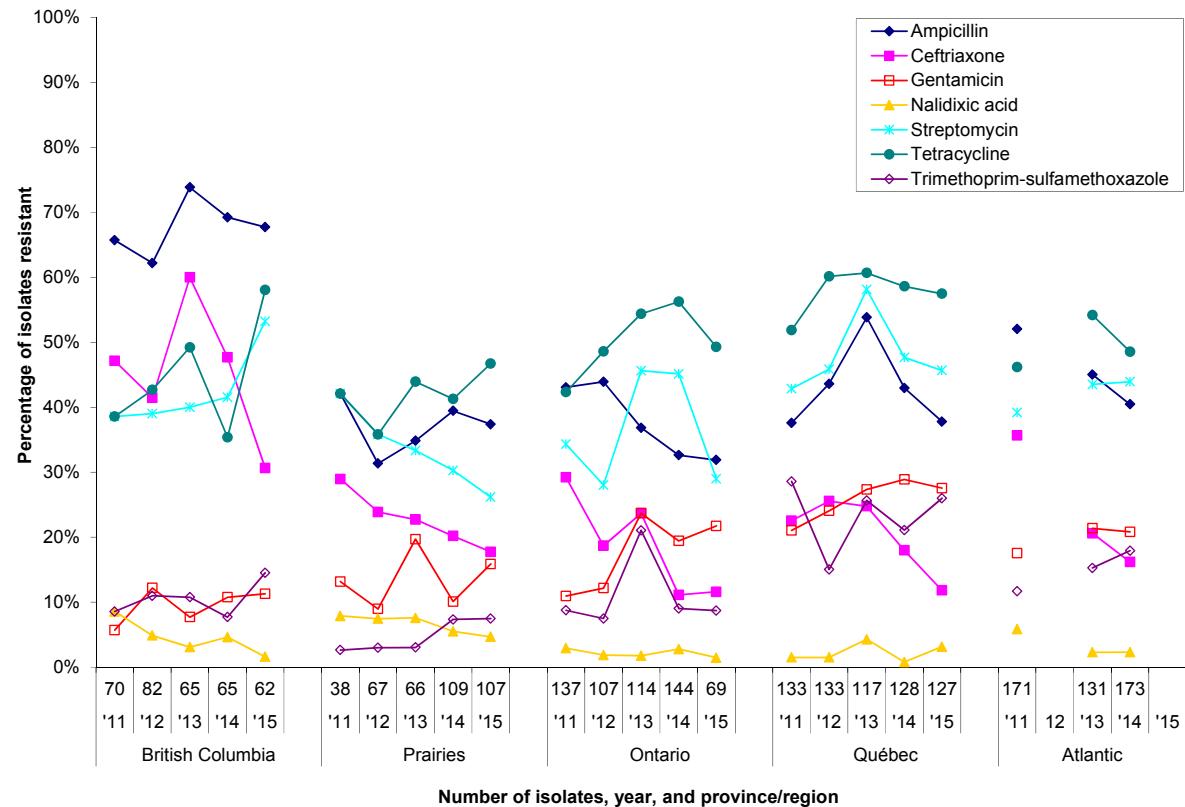
Province / region	British Columbia					Prairies					Ontario					Québec					Atlantic					
Year	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	
Number of isolates	64	53	33	36	69	29	46	45	81	77	119	102	94	75	26	100	106	94	92	109	49	43	59			
Antimicrobial																										
Ampicillin	38%	40%	33%	6%	14%	24%	17%	18%	7%	13%	33%	31%	26%	27%	12%	30%	29%	30%	27%	16%	29%	35%	34%			
Ceftriaxone	38%	40%	33%	6%	14%	24%	13%	18%	7%	9%	29%	23%	22%	27%	12%	29%	28%	30%	27%	15%	29%	30%	32%			
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	6%	8%	0%	2%	3%	7%	2%	1%	0%	5%	2%			
Nalidixic acid	0%	4%	0%	0%	4%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
Streptomycin	20%	26%	18%	14%	17%	31%	17%	20%	10%	14%	30%	24%	36%	28%	46%	50%	30%	31%	26%	50%	41%	19%	12%			
Tetracycline	22%	30%	27%	14%	19%	28%	20%	16%	7%	13%	31%	29%	33%	27%	50%	53%	31%	35%	28%	53%	43%	16%	12%			
Trimethoprim-sulfamethoxazole	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	2%	0%	0%	0%			

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Figure 4. 13 Temporal variations in resistance of *Escherichia coli* isolates from chicken, 2011–2015

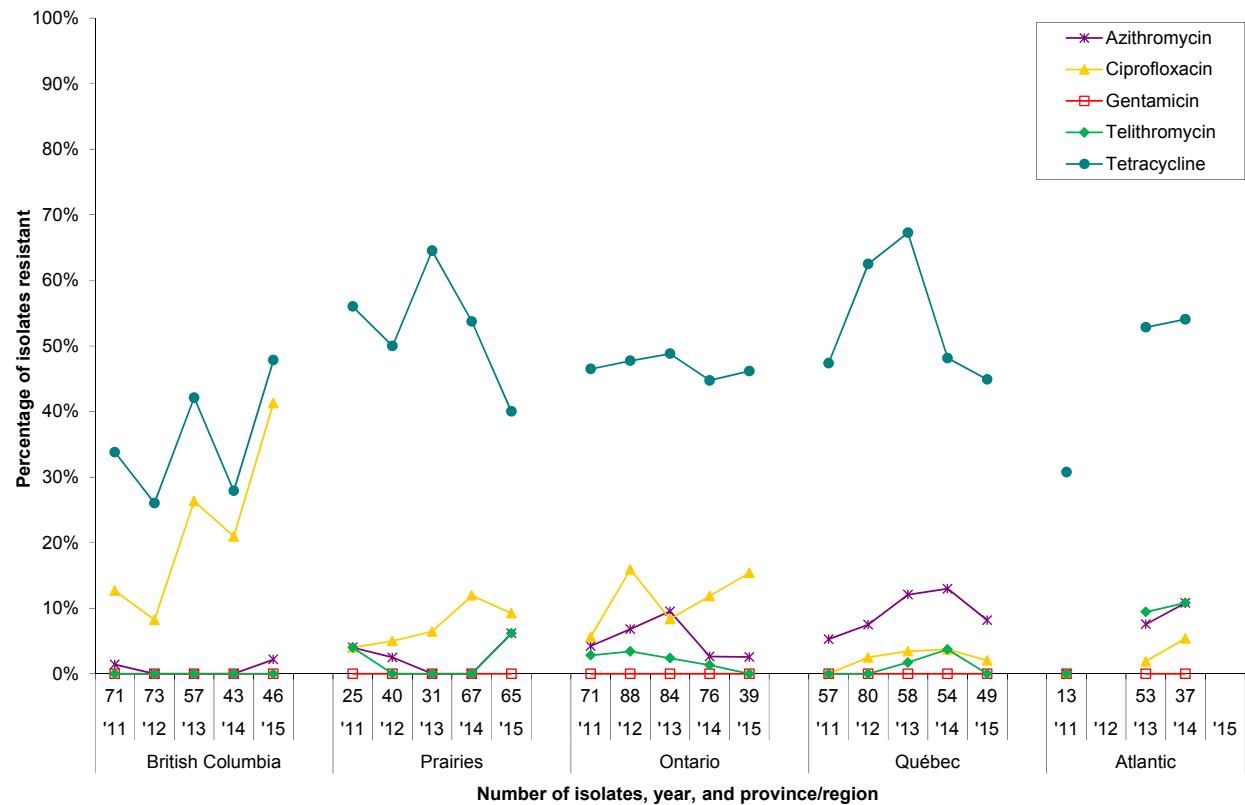
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Figure 4. 14 Temporal variations in resistance of *Campylobacter* isolates from chicken, 2011–2015



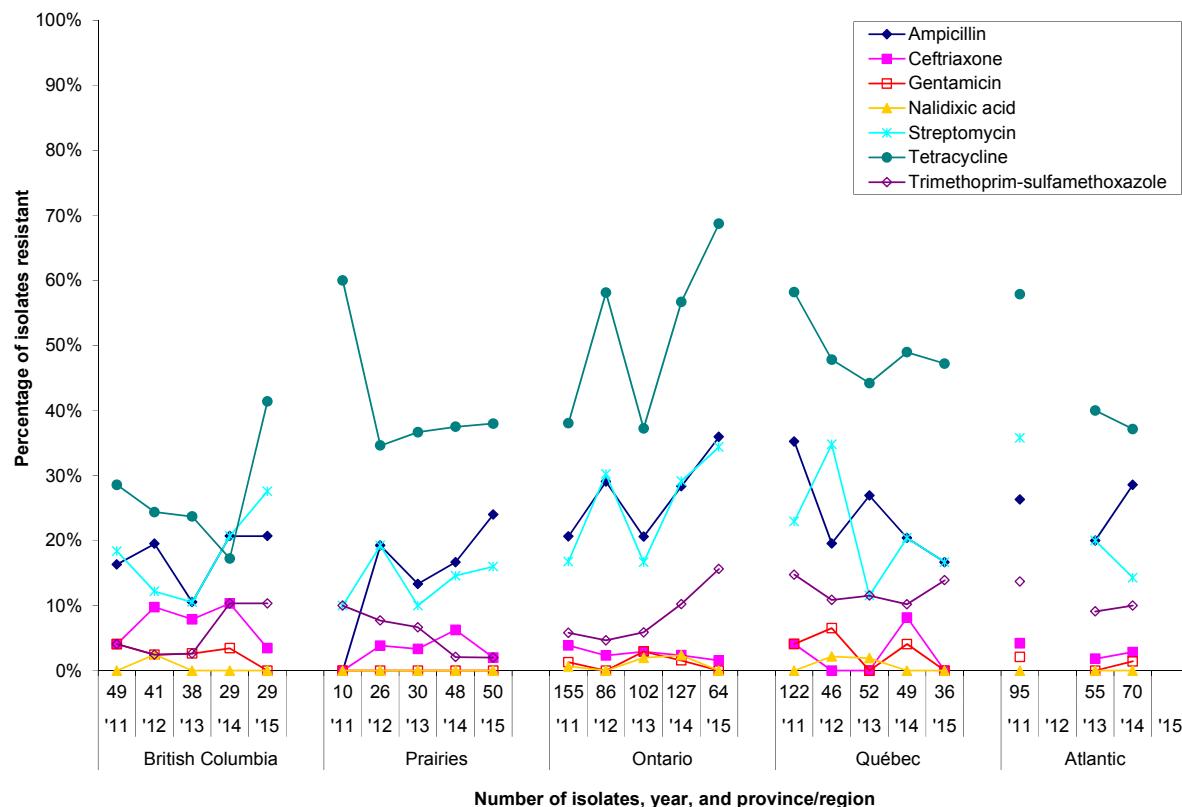
Province / region	British Columbia					Prairies					Ontario					Québec					Atlantic						
	Year	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	
Antimicrobial																											
Azithromycin		1%	0%	0%	0%	2%	4%	3%	0%	0%	6%	4%	7%	10%	3%	3%	5%	8%	12%	13%	8%	0%	8%	11%			
Ciprofloxacin		13%	8%	26%	21%	41%	4%	5%	6%	12%	9%	6%	16%	8%	12%	15%	0%	3%	3%	4%	2%	9%	2%	5%			
Gentamicin		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
Telithromycin		0%	0%	0%	0%	0%	4%	0%	0%	0%	6%	3%	3%	2%	1%	0%	0%	0%	0%	2%	4%	0%	0%	9%	11%		
Tetracycline		34%	26%	42%	28%	48%	56%	50%	65%	54%	40%	46%	48%	49%	45%	46%	47%	63%	67%	48%	45%	55%	53%	54%			

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Figure 4. 15 Temporal variations in resistance of *Escherichia coli* isolates from pork, 2011–2015

Province / region	British Columbia					Prairies					Ontario					Québec					Atlantic					
	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	
Year	49	41	38	29	29	10	26	30	48	50	155	86	102	127	64	122	46	52	49	36	95	55	70			
Antimicrobial																										
Ampicillin	16%	20%	11%	21%	21%	0%	19%	13%	17%	24%	21%	29%	21%	28%	36%	35%	20%	27%	20%	17%	26%	20%	29%			
Ceftriaxone	4%	10%	8%	10%	3%	0%	4%	3%	6%	2%	4%	2%	3%	2%	2%	4%	0%	0%	8%	0%	4%	2%	3%			
Gentamicin	4%	2%	3%	3%	0%	0%	0%	0%	0%	0%	1%	0%	3%	2%	0%	4%	7%	0%	4%	0%	2%	0%	1%			
Nalidixic acid	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	2%	2%	0%	0%	2%	2%	0%	0%	0%	0%	0%			
Streptomycin	18%	12%	11%	21%	28%	10%	19%	10%	15%	16%	17%	30%	17%	29%	34%	23%	35%	12%	20%	17%	36%	20%	14%			
Tetracycline	29%	24%	24%	17%	41%	60%	35%	37%	38%	38%	38%	58%	37%	57%	69%	58%	48%	44%	49%	47%	58%	40%	37%			
Trimethoprim-sulfamethoxazole	4%	2%	3%	10%	10%	10%	8%	7%	2%	2%	6%	5%	6%	10%	16%	15%	11%	12%	10%	14%	14%	9%	10%			

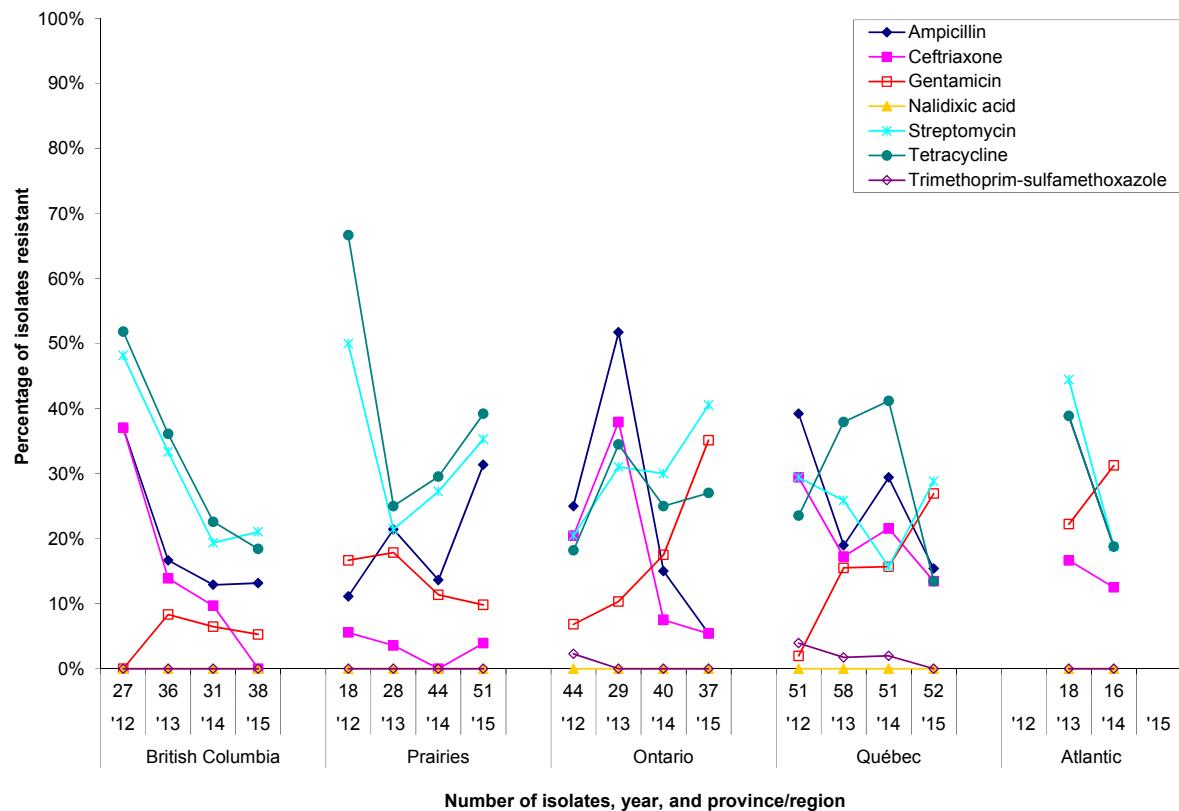
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

Figure 4. 16 Temporal variations in resistance of *Salmonella* isolates from turkey, 2012–2015



Province / region	British Columbia				Prairies				Ontario				Québec				Atlantic			
Year	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15
Number of isolates	27	36	31	38	18	28	44	51	44	29	40	37	51	58	51	52	18	16	18	16
Antimicrobial																				
Ampicillin	37%	17%	13%	13%	11%	21%	14%	31%	25%	52%	15%	5%	39%	19%	29%	15%	39%	19%	39%	19%
Ceftriaxone	37%	14%	10%	0%	6%	4%	0%	4%	20%	38%	8%	5%	29%	17%	22%	13%	17%	13%	17%	13%
Gentamicin	0%	8%	6%	5%	17%	18%	11%	10%	7%	10%	18%	35%	2%	16%	16%	27%	22%	31%	22%	31%
Nalidixic acid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptomycin	48%	33%	19%	21%	50%	21%	27%	35%	20%	31%	30%	41%	29%	26%	16%	29%	44%	19%	44%	19%
Tetracycline	52%	36%	23%	18%	67%	25%	30%	39%	18%	34%	25%	27%	24%	38%	41%	13%	39%	19%	39%	19%
Trimethoprim-sulfamethoxazole	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	4%	2%	2%	0%	0%	0%	0%	0%

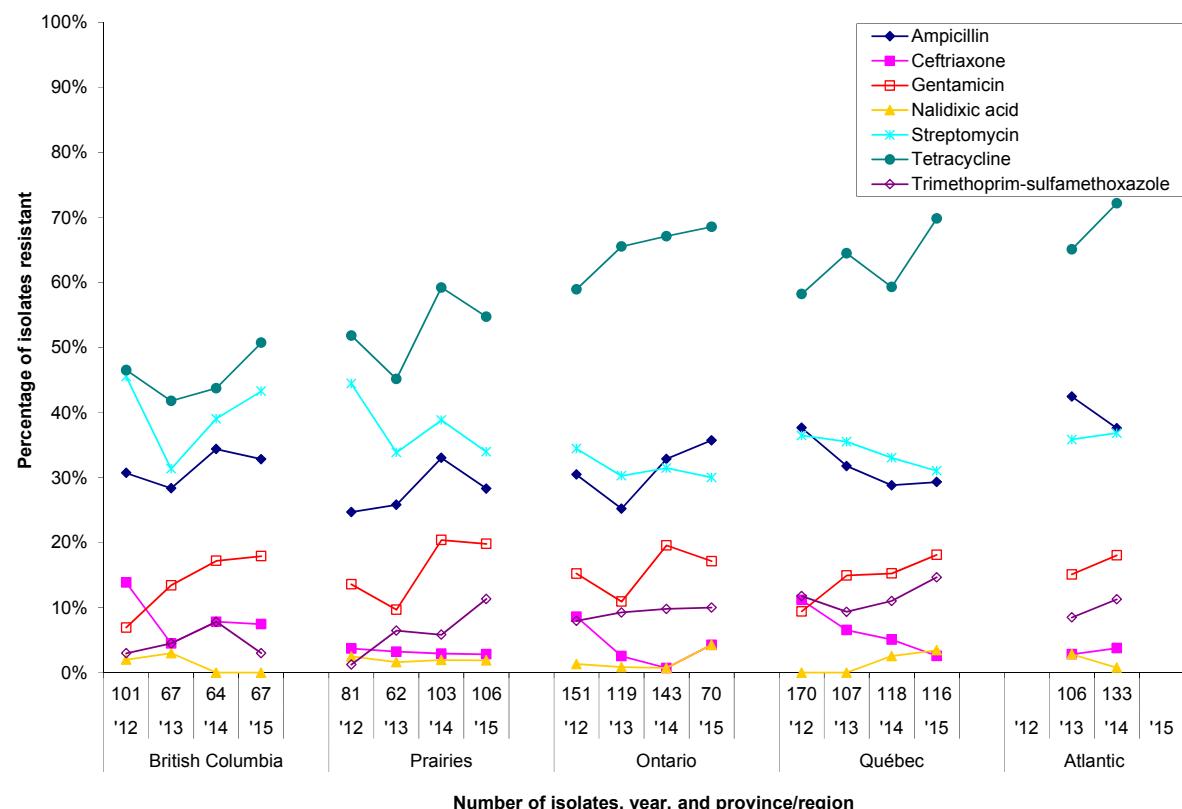
For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first year and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

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Figure 4. 17 Temporal variations in resistance of *Escherichia coli* isolates from turkey, 2012–2015

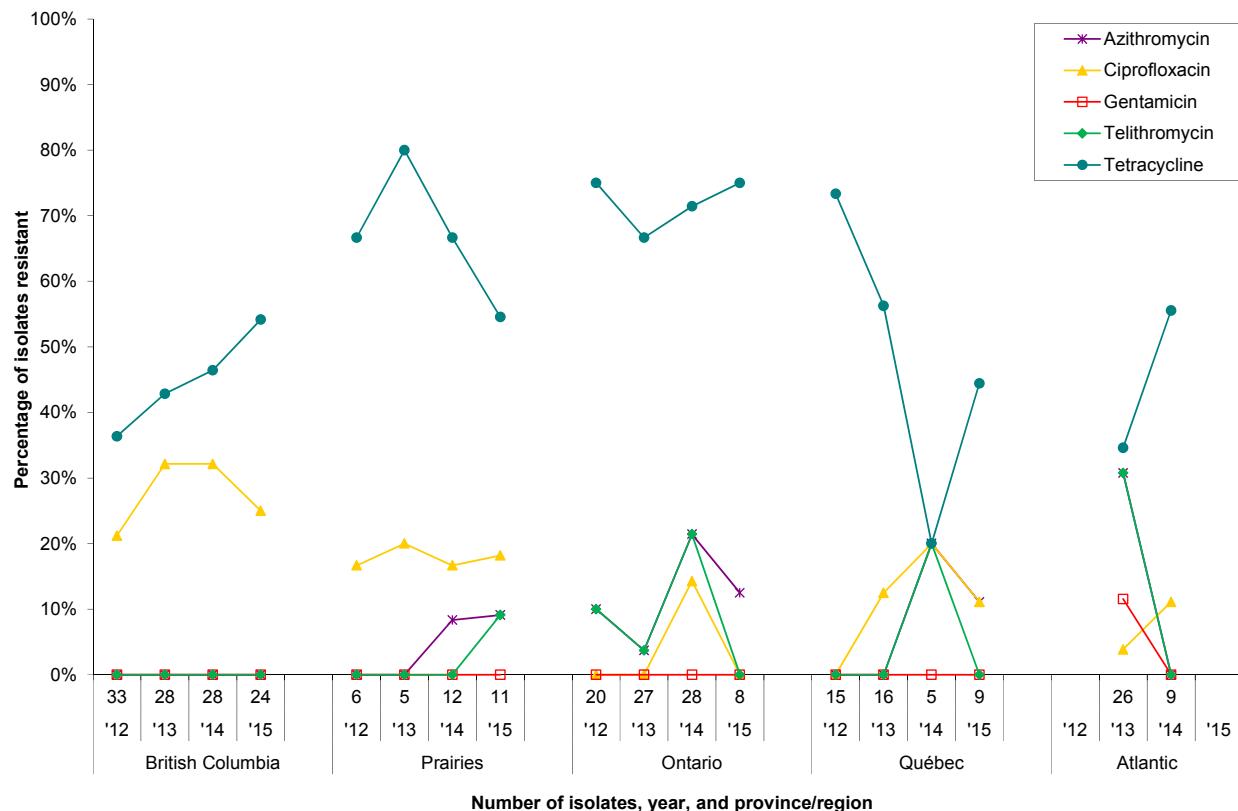
Province / region	British Columbia				Prairies				Ontario				Québec				Atlantic			
Year	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15
Number of isolates	101	67	64	67	81	62	103	106	151	119	143	70	170	107	118	116	106	133	106	133
Antimicrobial																				
Ampicillin	31%	28%	34%	33%	25%	26%	33%	28%	30%	25%	33%	36%	38%	32%	29%	29%	42%	38%		
Ceftriaxone	14%	4%	8%	7%	4%	3%	3%	3%	9%	3%	1%	4%	11%	7%	5%	3%	3%	4%		
Gentamicin	7%	13%	17%	18%	14%	10%	20%	20%	15%	11%	20%	17%	9%	15%	15%	18%	15%	18%		
Nalidixic acid	2%	3%	0%	0%	2%	2%	2%	2%	1%	1%	1%	4%	0%	0%	3%	3%	3%	1%		
Streptomycin	46%	31%	39%	43%	44%	34%	39%	34%	34%	30%	31%	30%	36%	36%	33%	31%	36%	37%		
Tetracycline	47%	42%	44%	51%	52%	45%	59%	55%	59%	66%	67%	69%	58%	64%	59%	70%	65%	72%		
Trimethoprim-sulfamethoxazole	3%	4%	8%	3%	1%	6%	6%	11%	8%	9%	10%	10%	12%	9%	11%	15%	8%	11%		

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

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Figure 4. 18 Temporal variations in resistance of *Campylobacter* isolates from turkey, 2012–2015

Province/region	British Columbia				Prairies				Ontario				Québec				Atlantic			
Year	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15
Number of isolates	33	28	28	24	6	5	12	11	20	27	28	8	15	16	5	9	26	9	9	15
Antimicrobial																				
Azithromycin	0%	0%	0%	0%	0%	0%	8%	9%	10%	4%	21%	13%	0%	0%	20%	11%	31%	0%		
Ciprofloxacin	21%	32%	32%	25%	17%	20%	17%	18%	0%	0%	14%	0%	0%	13%	20%	11%	4%	11%		
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%		
Telithromycin	0%	0%	0%	0%	0%	0%	9%	0%	10%	4%	21%	0%	0%	0%	20%	0%	31%	0%		
Tetracycline	36%	43%	46%	54%	67%	80%	67%	55%	75%	67%	71%	75%	0%	56%	20%	44%	35%	56%		

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first year and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Due to unforeseen and lengthy delays in retail sampling in the Atlantic region in 2012 and no samples collected in 2015, data are not presented for these years in the interest of precision.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

RECOVERY RESULTS

Table 4. 10 Retail Meat Surveillance recovery rates, 2003–2015

CIPARS Component / Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted				
			<i>Escherichia coli</i>	Salmonella	Campylobacter	Enterococcus	
Beef	British Columbia	2005	93%	27/29			
		2007	79%	49/62			
		2008	77%	88/115			
		2009	71%	79/112			
		2010	51%	64/125			
		2011	53%	57/107			
		2012	60%	76/126			
		2013	47%	40/85			
		2014	43%	43/100			
		2015	42%	45/108			
Prairies	Prairies	2005	79%	120/151			
		2006	76%	123/161			
		2007	78%	118/151			
		2008	76%	134/177			
		2009	83%	135/163			
		2010	80%	107/134			
		2011 ^a	75%	54/72			
		2012	75%	80/107			
		2013	53%	48/90			
		2014	53%	97/184			
		2015	46%	86/186			
Ontario	Ontario	2003	66%	101/154	2%	2/84	3%
		2004	80%	190/237			
		2005	81%	184/227			
		2006	81%	189/235			
		2007	71%	184/227			
		2008	78%	185/236			
		2009	79%	195/248			
		2010	69%	123/177			
		2011	73%	161/222			
		2012	63%	110/176			
		2013	58%	104/180			
		2014	51%	121/236			
		2015	46%	53/116			
Québec	Québec	2003	57%	84/147	0%	0/33	0%
		2004	56%	137/245			
		2005	56%	126/225			
		2006	50%	109/215			
		2007	68%	147/216			
		2008	59%	126/214			
		2009	54%	108/201			
		2010	46%	102/223			
		2011	45%	91/204			
		2012	51%	107/219			
		2013	42%	74/175			
		2014	41%	85/207			
		2015	39%	79/203			
Atlantic	Atlantic	2004	67%	16/24			
		2007	52%	16/31			
		2008	70%	39/56			
		2009	69%	137/200			
		2010	69%	126/183			
		2011	58%	110/191			
		2012 ^d	50%	24/48			
		2013	58%	83/143			
		2014	57%	118/207			
		2015 ^e					

See corresponding footnotes at the end of the table.

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Table 4. 10 Retail Meat Surveillance recovery rates, 2003–2015 (cont'd)

CIPARS Component / Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted							
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>				
Chicken	British Columbia	2005	95%	19/20	13%	5/39	69%	27/39	100%	20/20
		2007	98%	42/43	22% ^b	18/81	35%	28/80	100%	34/34
		2008	90%	70/78	32%	47/145	34%	50/145	100%	78/78
		2009	95%	70/74	40%	59/146	53%	78/146	97%	72/74
		2010	89%	75/84	34%	56/166	42%	70/166		
		2011	96%	70/73	45%	64/143	50%	71/143		
		2012	99%	82/83	32%	53/166	44%	73/166		
		2013	95%	57/60	24%	28/118	42%	50/118		
		2014	98%	65/66	27%	36/133	32%	43/133		
		2015	91%	62/68	51%	69/136	35%	47/136		
Prairies	Prairies	2005	98%	81/83	14%	21/153	37%	53/145	98%	83/85
		2006	98%	85/86	16%	25/153	33%	51/155	98%	85/87
		2007	97%	75/77	31% ^b	43/141	35%	49/141	100%	77/77
		2008	99%	91/92	40%	64/161	25%	41/161	100%	92/92
		2009	98%	90/92	47%	71/150	32%	48/150	100%	92/92
		2010	90%	71/79	32%	42/132	28%	37/132		
		2011 ^a	97%	38/39	40%	29/73	34%	25/73		
		2012	94%	67/71	33%	46/140	29%	40/140		
		2013	97%	58/60	32%	38/120	20%	24/120		
		2014	97%	109/112	36%	81/222	30%	67/222		
Ontario	Ontario	2003	95%	137/144	16%	27/167	47%	78/166	99%	143/144
		2004	95%	150/158	17%	54/315	45%	143/315	100%	158/158
		2005	95%	145/153	9%	26/303	40%	120/303	99%	150/152
		2006	97%	152/156	12%	36/311	34%	104/311	98%	154/156
		2007	98%	157/161	54% ^b	172/320	37%	117/320	100%	161/161
		2008	96%	150/156	45%	139/311	39%	121/311	99%	154/156
		2009	95%	155/164	43%	142/328	31%	101/328	100%	164/164
		2010	86%	100/116	39%	90/232	28%	64/232		
		2011	93%	137/147	40%	119/294	24%	71/293		
		2012	92%	107/116	44%	102/232	39%	87/226		
		2013	93%	110/118	39%	89/231	35%	83/234		
		2014	92%	144/157	24%	75/312	25%	78/312		
		2015	91%	69/76	17%	26/151	26%	40/151		
Québec	Québec	2003	89%	112/126	16%	29/171	55%	94/170	100%	125/125
		2004	96%	157/161	17%	53/320	50%	161/322	100%	161/161
		2005	95%	142/149	9%	26/300	34%	103/299	100%	150/150
		2006	94%	135/144	12%	33/288	35%	100/288	100%	144/144
		2007	90%	129/144	40% ^b	113/287	21%	59/287	99%	143/144
		2008	91%	131/144	42%	120/287	19%	54/287	100%	144/144
		2009	94%	126/134	39%	105/267	20%	52/266	99%	132/134
		2010	93%	138/148	39%	116/296	21%	63/296		
		2011	99%	134/136	37%	100/272	21%	57/272		
		2012	95%	133/140	38%	106/280	28%	78/274		
		2013	90%	105/117	37%	89/243	23%	55/243		
		2014	93%	129/138	33%	92/276	20%	54/276		
		2015	93%	127/136	40%	109/272	18%	49/272		
Atlantic	Atlantic	2004	100%	13/13	4%	1/25	40%	10/25	100%	13/13
		2007 ^c	91%	29/32	22% ^b	7/32				
		2008 ^c	68%	38/56	22%	12/56				
		2009 ^c	94%	187/199	49%	97/199	29%	57/199		
		2010	93%	176/190	41%	77/190	37%	70/190		
		2011	89%	171/192	28%	53/192	30%	57/192		
		2012 ^d	96%	46/48	23%	11/48	21%	10/48		
		2013	92%	133/144	31%	44/144	47%	67/144		
		2014	86%	179/207	31%	64/207	25%	52/206		
		2015 ^e								

See corresponding notes at the end of the table.

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Table 4. 10 Retail Meat Surveillance recovery rates, 2003–2015 (cont'd)

CIPARS Component / Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted				
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>	
Pork	British Columbia	2005	31%	10/32			
		2007	29%	23/79	1%	1/79	
		2008	30%	44/148	2%	3/148	
		2009	26%	38/145	1%	2/145	
		2010	19%	31/166	1%	2/167	
		2011	27%	49/180	2%	3/180	
		2012	25%	41/167	0%	0/167	
		2013	28%	33/118	0%	0/118	
		2014	22%	29/131	2%	2/132	
		2015	21%	29/136			
Prairies	Prairies	2005	30%	48/162			
		2006	30%	49/165	2%	3/134	
		2007	25%	38/154	2%	3/154	
		2008	23%	41/176	1%	1/176	
		2009	18%	29/164	0%	0/164	
		2010	12%	17/142	1%	1/142	
		2011 ^a	11%	10/90	1%	1/90	
		2012	19%	26/140	1%	2/141	
		2013	24%	28/119	3%	3/120	
		2014	22%	48/223	1%	3/223	
		2015	23%	50/220			
Ontario	Ontario	2003	58%	90/154	1%	1/93	0%
		2004	71%	198/279		0/76	87%
		2005	59%	179/303		66/76	
		2006	59%	182/311	< 1%	1/255	
		2007	54%	172/320	2%	6/319	
		2008	50%	155/312	2%	7/310	
		2009	41%	136/328	2%	8/327	
		2010	38%	84/224	0%	0/224	
		2011	42%	155/371	2%	6/370	
		2012	37%	86/231	2%	5/231	
		2013	43%	100/233	1%	3/232	
		2014	41%	127/312	2%	6/312	
		2015	42%	64/152			
Québec	Québec	2003	42%	61/147	3%	1/32	9%
		2004	38%	109/290		3/32	82%
		2005	26%	79/300		28/34	
		2006	20%	57/287	0%	0/232	
		2007	22%	64/287	1%	3/288	
		2008	21%	60/287	2%	5/286	
		2009	15%	41/268	1%	3/268	
		2010	16%	47/296	1%	4/296	
		2011	32%	122/387	4%	17/387	
		2012	16%	46/279	3%	8/279	
		2013	20%	48/239	<1%	1/239	
		2014	18%	49/276	<1%	2/276	
		2015	13%	36/272			
Atlantic	Atlantic	2004	58%	14/24			
		2007	39%	13/31	3%	1/30	
		2008	30%	17/56	2%	1/56	
		2009	41%	82/200	3%	5/199	
		2010	39%	74/190	4%	8/190	
		2011	43%	95/223	3%	7/221	
		2012 ^d	25%	12/48	0%	0/48	
		2013	40%	57/143	1%	2/142	
		2014	41%	86/209	6%	13/208	
		2015 ^e					

See corresponding notes at the end of the table.

Table 4. 10 Retail Meat Surveillance recovery rates, 2003–2015 (cont'd)

CIPARS Component / Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted				
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>	
Turkey	British Columbia	2011	97% 59/61	11% 8/71	24% 17/71		
		2012	97% 101/104	18% 27/153	22% 33/153		
		2013	98% 59/60	26% 30/115	22% 25/115		
		2014	97% 64/66	25% 31/122	23% 28/122		
		2015	99% 67/68	32% 38/118	20% 24/118		
	Prairies	2011 ^a	100% 10/10	20% 2/10	10% 1/10		
		2012	91% 81/89	14% 18/128	5% 6/128		
		2013	90% 56/62	23% 25/107	4% 4/105		
		2014	93% 103/111	22% 44/196	7% 13/196		
		2015	99% 106/107	31% 51/165	7% 11/165		
Ontario	Ontario	2011	95% 162/171	14% 27/191	9% 18/191		
		2012	97% 152/156	20% 44/223	9% 20/223		
		2013	95% 115/121	12% 28/228	12% 27/227		
		2014	92% 143/156	13% 40/310	9% 28/310		
		2015	92% 70/76	24% 37/152	5% 8/152		
Québec	Québec	2011	91% 138/152	17% 27/163	10% 16/163		
		2012	96% 170/178	21% 51/246	6% 15/246		
		2013	89% 98/110	32% 57/177	9% 16/178		
		2014	86% 119/138	19% 51/262	2% 5/262		
		2015	86% 116/135	21% 52/247	4% 9/247		
Atlantic	Atlantic	2013	85% 107/126	19% 24/126	23% 29/124		
		2014	76% 143/187	12% 23/187	8% 15/185		
		2015 ^e					

Grey-shaded areas indicate either: a) isolates recovered from sampling activities outside the scope of CIPARS routine (or "core") surveillance in the specified year (i.e., grey-shaded areas with data) or b) discontinuation or no surveillance activity (i.e., grey-shaded areas with no data).

The Prairies is a region including the provinces Alberta and Saskatchewan.

For Ontario in 2015, a partial year of retail sampling was conducted due to difficulties in staffing field personnel. As a result, the sampling target and subsequent isolate yields in this province were not achieved and results should be interpreted with caution.

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

^a In 2011, due to an unforeseeable pause in retail sampling in Saskatchewan of approximately 3 months, the expected number of samples was not met and thus, results for this province for this year should be interpreted with caution.

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

^c For the Atlantic region, recovery results are not presented for *Campylobacter* in 2007 and 2008 as well as for *Enterococcus* in 2007, 2008, and 2009 due to concerns regarding harmonization of laboratory methods.

^d Due to an unforeseeable pause in retail sampling in the Atlantic region from April through December in 2012, the expected number of samples was not achieved and thus, results for this region in 2012 are not representative and potentially lack the precision necessary to be included as regular surveillance data. For this reason, these data are not presented anywhere else in this report.

^e No retail sampling was conducted in the Atlantic region in 2015.

ABATTOIR SURVEILLANCE

KEY FINDINGS

A summary of *Abattoir Surveillance* recovery rates are presented in Table 4. 19.

BEEF CATTLE

ESCHERICHIA COLI (n = 149)

In 2015, there were no isolates resistant to ceftiofur, nalidixic acid or Category I antimicrobials (antimicrobials of very high importance in human medicine) (Table 4. 11).

CAMPYLOBACTER (n = 129)

Five isolates (4%, 5/129) were resistant to 4 classes of antimicrobials in 2015; in comparison, the maximum number of classes isolates were resistant to in 2014 was 3 (Table 4. 12).

The upward trend in resistance to ciprofloxacin observed since 2011 (1%) continued in 2015 (5%, 7/129), although this difference was not significant (Figure 4. 20). The proportion of isolates resistant to azithromycin and telithromycin was significantly higher in 2015 (6%, 8/129; 7%, 9/129, respectively) than in 2014 (1%, 1/121; 1%, 1/121), 2011 (0%, 0/108; 0%, 0/108), and 2006 (0%, 0/105; 0%, 0/105) (Figure 4. 20). The proportion of isolates resistant to tetracycline was significantly higher in 2015 (59%, 76/129) than in 2006 (46%, 48/105) (Figure 4. 20).

CHICKENS

SALMONELLA (n = 129)

In 2015, 3% (1/31) of Enteritidis isolates were resistant to one or more tested antimicrobials. One Typhimurium isolate was resistant to 4 classes of antimicrobials. This level of multiclass resistance was not seen since 2012 (Table 4. 13).

The proportion of isolates resistant to ampicillin was significantly lower in 2015 (6%, 8/129) than in 2011 (36%, 51/140) and 2006 (16%, 29/187) (Figure 4. 21). The proportion of isolates resistant to ceftriaxone was significantly lower in 2015 (6%, 8/129) than in 2011 (31%, 44/140) (Figure 4. 21). The proportion of isolates resistant to tetracycline was significantly higher in 2015 (43%, 56/129) than in 2003 (19%, 24/126, data not shown).

ESCHERICHIA COLI (n = 179)

The proportion of isolates resistant to tetracycline was significantly lower in 2015 (54%, 97/179) than in 2003 (69%, 106/153, data not shown). The proportion of isolates resistant to trimethoprim-sulfamethoxazole was significantly higher in 2015 (20%, 36/179) than in 2003 (8%, 12/153, data not shown). The proportion of isolates resistant to streptomycin was

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significantly higher in 2015 (51%, 92/179) than in 2006 (34%, 56/167) (Figure 4. 22). The proportion of isolates resistant to gentamicin was significantly higher in 2015 (22%, 39/179) than in 2011 (13%, 22/164) and 2006 (8%, 14/167) (Figure 4. 22).

CAMPYLOBACTER (n = 143)

Of the *Campylobacter* species isolates, the proportion of *C. jejuni* has decreased from 89% (123/138) in 2013 to 64% (121/188) in 2014 and 78% (112/143) in 2015 (Table 4. 15). In comparison, the proportion of *C. coli* has increased over the same time period from 9% (12/138) in 2013 to 14% (27/188) in 2014 and 22% (31/143) in 2015 (Table 4. 15).

The proportion of isolates resistant to ciprofloxacin was significantly higher in 2015 (20%, 29/143) than in 2014 (11%, 20/188) and 2011 (9%, 11/117) (Figure 4. 23).

PIGS

SALMONELLA (n = 211)

The proportion of isolates resistant to ceftriaxone increased to 5% (11/211) in 2015 from 1% in 2006 (1/145) and 2011 (2/165) although this difference was not significant (Figure 4. 24).

ESCHERICHIA COLI (n = 192)

The proportion of isolates susceptible to all antimicrobials tested increased from 12% (20/161) in 2014 to 21% (40/192) in 2015 while the proportion of isolates resistant to one class of antimicrobials decreased from 26% (42/161) in 2014 to 19% (37/192) in 2015 (Table 4. 17). The proportion of isolates resistant to tetracycline was significantly lower in 2015 (70%, 134/192) than in 2006 (83%, 95/114) (Figure 4. 25).

CAMPYLOBACTER (n = 279)

The proportion of isolates resistant to ciprofloxacin significantly decreased to 6% (16/279) in 2015 from 11% (25/236) in 2014 (Figure 4. 26).

MULTICLASS RESISTANCE

Table 4. 11 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from beef cattle, 2015

Animal species	Number of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Beef cattle	149	96	30	20	3		17	4						17			4			50

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 12 Number of antimicrobial classes in resistance patterns of *Campylobacter* from beef cattle, 2015

Species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial									
		0	1	2–3	4–5	6–7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET		
<i>Campylobacter jejuni</i>	97 (75.2)	40	50	7									7	7			57
<i>Campylobacter coli</i>	30 (23.3)	9	12	4	5			9		8	8	8					18
<i>Campylobacter</i> spp.	2 (1.6)	1	1										2				1
Total	129 (100)	49	63	12	5			9		8	8	8	7	9			76

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 13 Number of antimicrobial classes in resistance patterns of *Salmonella* from chickens, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial											
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL
Kentucky	41 (31.8)	4	1	36			1	36	1	1	1	1	1	1					37
Enteritidis	31 (24.0)	30	1																1
Heidelberg	12 (9.3)	9	1	2			1	2	2	2	2	2	2	1					1
Typhimurium	10 (7.8)	1	8	1			1	2	2	2	2	2	2	9					9
Infantis	9 (7.0)	8	1														1		
Schwarzengrund	5 (3.9)	3	2						1	1	1	1	1						1
Livingstone	4 (3.1)		4																4
Braenderup	3 (2.3)	2	1						1	1	1	1	1						
Thompson	3 (2.3)		3																
Less common serovars	11 (8.5)	7	1	3			3		1	1	1	1	1	11					3
Total	129 (100)	67	12	49	1		2	42	8	8	8	8	8				1		56

Antimicrobial abbreviations are defined in the Appendix.

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

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

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Table 4. 14 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from chickens, 2015

Animal species	Number of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial										
		Aminoglycosides						β-Lactams				Folate pathway inhibitors		Macrolides		Phenicols		Quinolones	
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL
Chickens	179	37	31	75	36		39	92	73	25	28	25	28	91	36		13	9	97

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 15 Number of antimicrobial classes in resistance patterns of *Campylobacter* from chickens, 2015

Species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides						Ketolides	Lincosamides	Macrolides	Phenicols	Quinolones	Tetracyclines	TEL	CLI	AZM	ERY	FLR	CIP	NAL	
		0	1	2–3	4–5	6–7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET	AZM	ERY	FLR	CIP	NAL	
<i>Campylobacter jejuni</i>	112 (78.3)	57	39	16												1	1	18	18	52	
<i>Campylobacter coli</i>	31 (21.7)	15	3	9	4											4	4	4	11	11	14
Total	143 (100)	72	42	25	4											4	4	5	29	29	66

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 16 Number of antimicrobial classes in resistance patterns of *Salmonella* from pigs, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides						β-Lactams				Folate pathway inhibitors		Macrolides		Phenicols		Quinolones		Tetracyclines	
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET	
Derby	42 (19.9)	8	5	22	7				29	8	4	4	4	4	29					32	
Typhimurium	23 (10.9)	3	6	5	8	1			12	12					13	3	2	8		17	
Infantis	20 (9.5)	19	1																	1	
4,[5],12:i:-	15 (7.1)	2	3	10				13	13	1	1	1	1	1	12	1				13	
Uganda	13 (6.2)	13															2			13	
Brandenburg	12 (5.7)	10	2																	2	
Ohio	11 (5.2)	5		6			6	6						6	1		6			5	
Bovis/morbificans	8 (3.8)	8																			
Schwarzengrund	8 (3.8)	7	1												1	1					
London	7 (3.3)	4		2	1			1	1						3	2				3	
Ohio var. 14+	6 (2.8)	2	2	1	1	2		2	2	1	1	1	1	4	3	1	2			2	
Worthington	5 (2.4)	3	2																	2	
Less common serovars	41 (19.4)	22	2	8	9		4	17	10	5	5	5	5	15	2		3			18	
Total	211 (100)	104	23	40	42	2		80	52	11	11	11	11	83	13	3	21			95	

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 17 Number of antimicrobial classes in resistance patterns of *Escherichia coli* from pigs, 2015

Animal species	Number of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial pathway											
		Aminoglycosides		β-Lactams					Folate pathway inhibitors		Macrolides		Phenicols		Quinolones		Tetracyclines			
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Pigs	192	40	37	86	29		3	67	68	3	3	3	3	77	30	1	26	2		134

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 18 Number of antimicrobial classes in resistance patterns of *Campylobacter* from pigs, 2015

Species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial									
		0	1	2–3	4–5	6–7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET			
<i>Campylobacter coli</i>	274 (98.2)	44	84	62	84				114	119	136	136		16	16		205	
<i>Campylobacter</i> spp.	4 (1.4)		1	1	2				2	2	3	3		3		3		3
<i>Campylobacter jejuni</i>	1 (0.4)			1					1		1	1			1			1
Total	279 (100)	44	85	64	86				117	121	140	140		16	19		209	

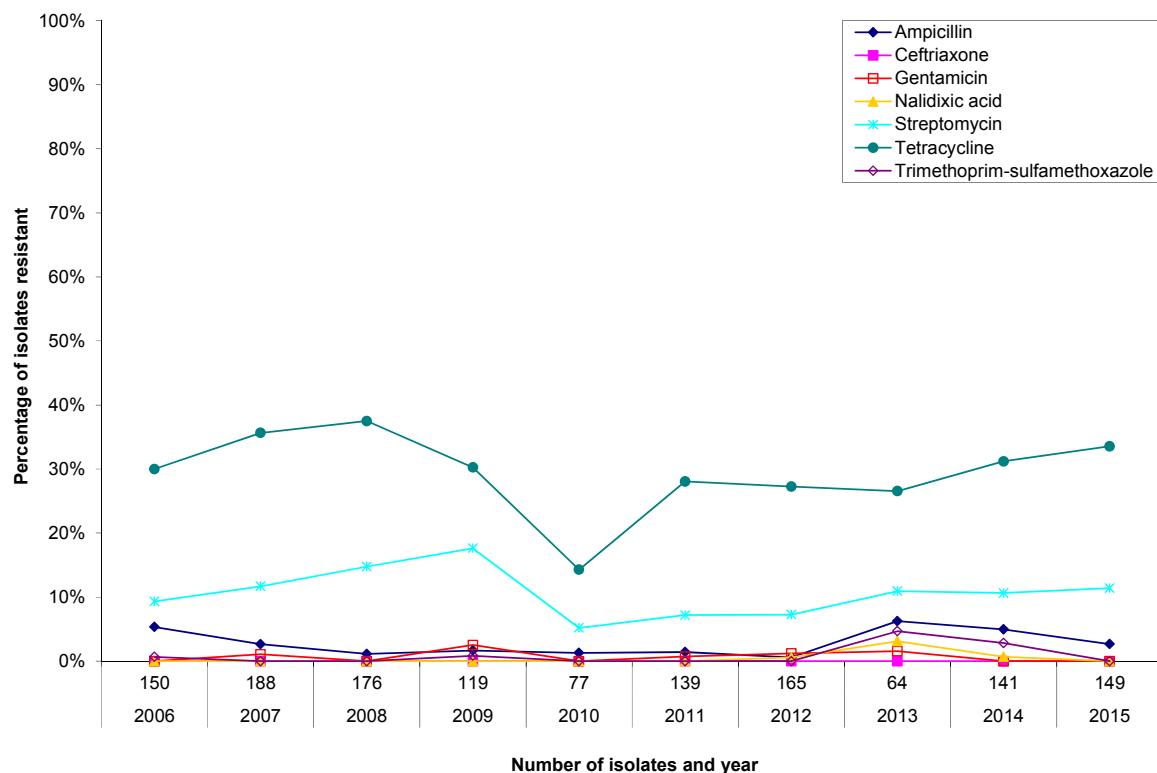
Antimicrobial abbreviations are defined in the Appendix.

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

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

TEMPORAL ANTIMICROBIAL RESISTANCE SUMMARY

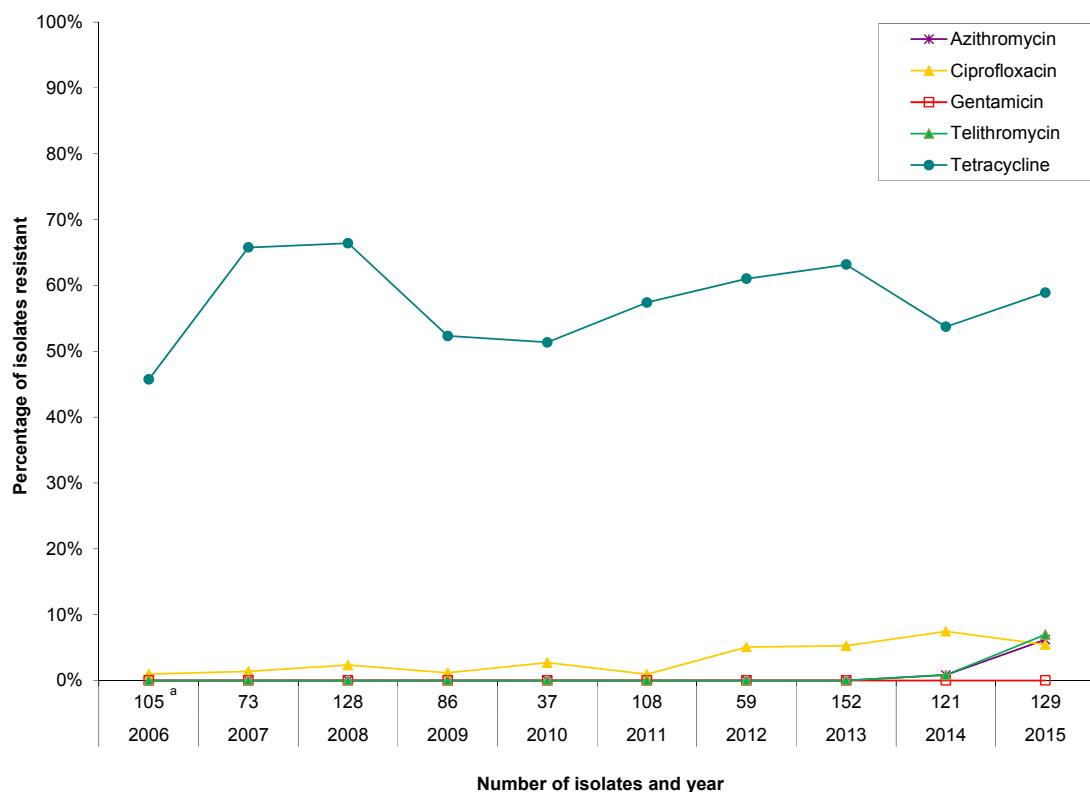
Figure 4.19 Temporal variations in resistance of *Escherichia coli* isolates from beef cattle, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	150	188	176	119	77	139	165	64	141	149
Antimicrobial										
Ampicillin	5%	3%	1%	2%	1%	1%	1%	6%	5%	3%
Ceftriaxone	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gentamicin	0%	1%	0%	3%	0%	1%	1%	2%	0%	0%
Nalidixic acid	0%	0%	0%	0%	0%	0%	1%	3%	1%	0%
Streptomycin	9%	12%	15%	18%	5%	7%	7%	11%	11%	11%
Tetracycline	30%	36%	38%	30%	14%	28%	27%	27%	31%	34%
Trimethoprim-sulfamethoxazole	1%	0%	0%	1%	0%	0%	0%	5%	3%	0%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years, 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 20 Temporal variations in resistance of *Campylobacter* isolates from beef cattle, 2006–2015

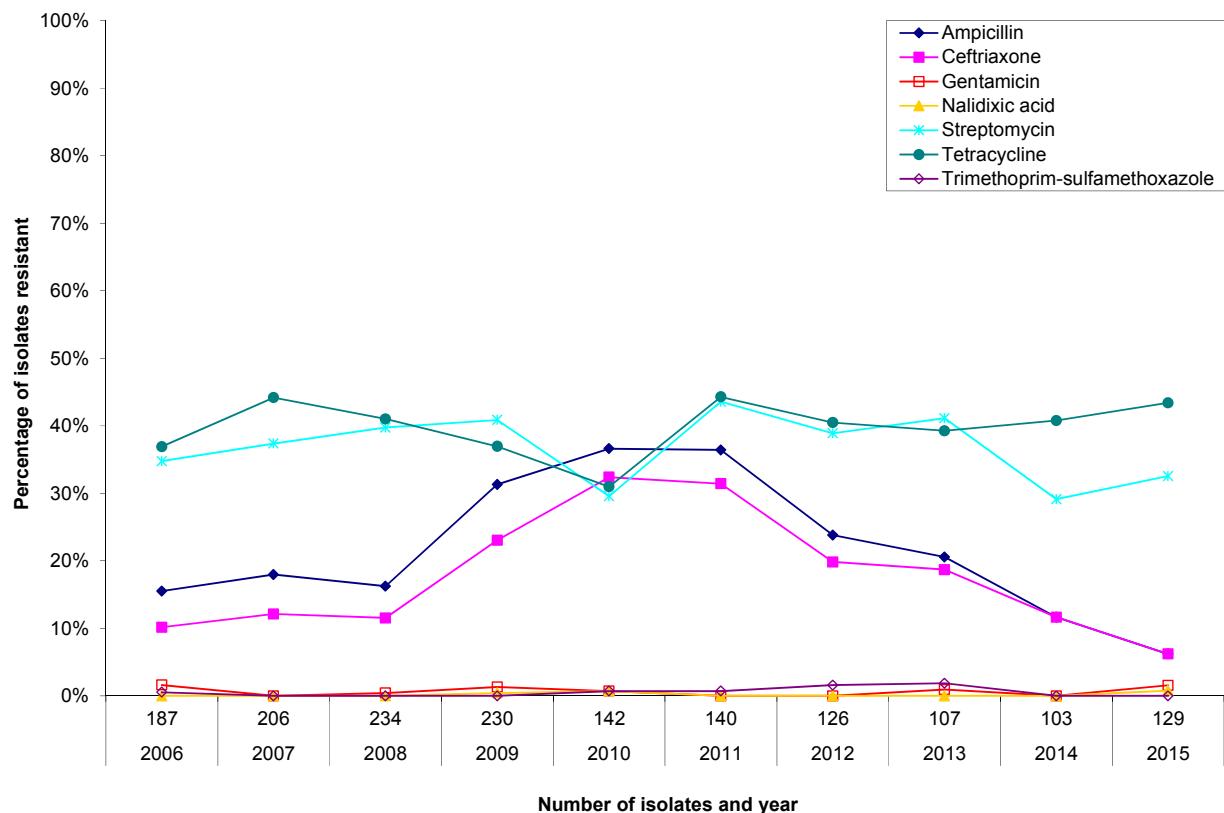


Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	105 ^a	73	128	86	37	108	59	152	121	129
Antimicrobial										
Azithromycin	0%	0%	0%	0%	0%	0%	0%	0%	1%	6%
Ciprofloxacin	1%	1%	2%	1%	3%	1%	5%	5%	7%	5%
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Telithromycin	0%	0%	0%	0%	0%	0%	0%	0%	1%	7%
Tetracycline	46%	66%	66%	52%	51%	57%	61%	63%	54%	59%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance years, the previous 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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

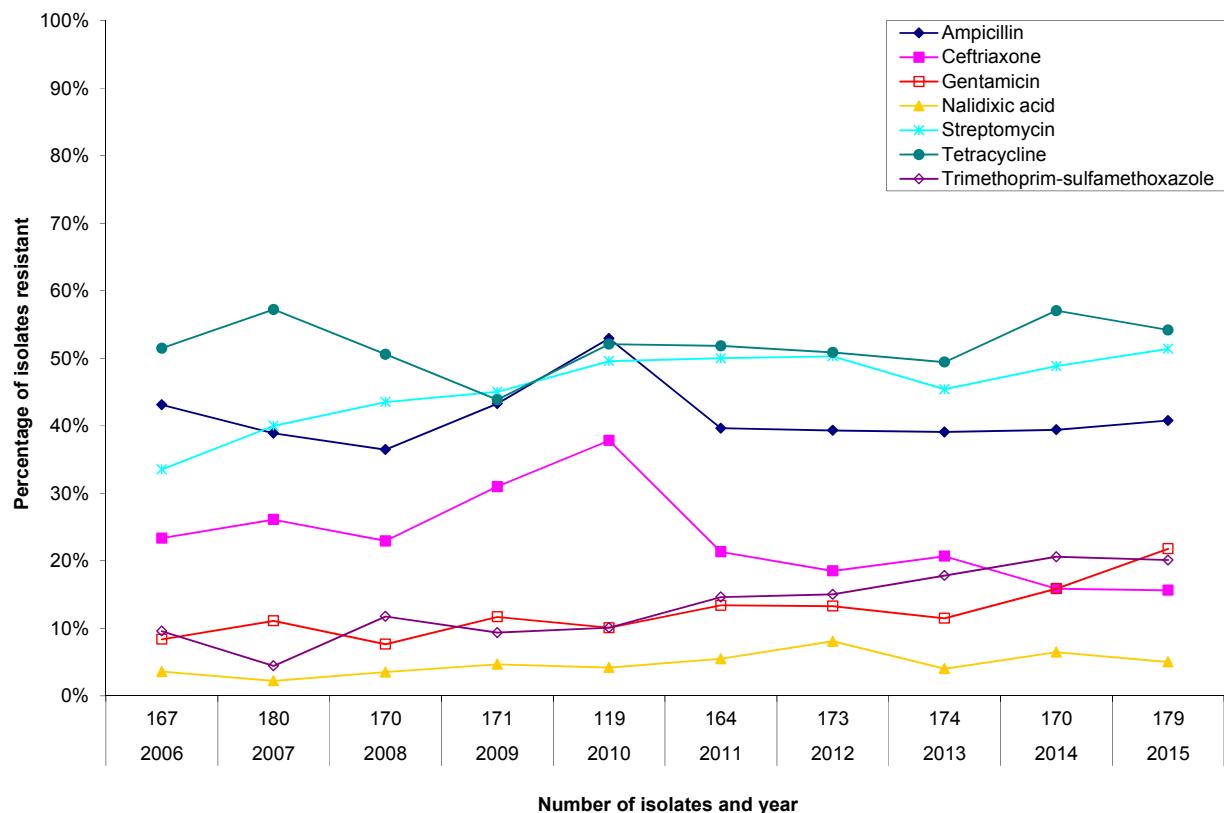
Figure 4. 21 Temporal variations in resistance of *Salmonella* isolates from chickens, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	187	206	234	230	142	140	126	107	103	129
Antimicrobial										
Ampicillin	16%	18%	16%	31%	37%	36%	24%	21%	12%	6%
Ceftriaxone	10%	12%	12%	23%	32%	31%	20%	19%	12%	6%
Gentamicin	2%	0%	0%	1%	1%	0%	0%	1%	0%	2%
Nalidixic acid	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%
Streptomycin	35%	37%	40%	41%	30%	44%	39%	41%	29%	33%
Tetracycline	37%	44%	41%	37%	31%	44%	40%	39%	41%	43%
Trimethoprim-sulfamethoxazole	1%	0%	0%	0%	1%	1%	2%	2%	0%	0%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years, 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 22 Temporal variations in resistance of *Escherichia coli* isolates from chickens, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	167	180	170	171	119	164	173	174	170	179
Antimicrobial										
Ampicillin	43%	39%	36%	43%	53%	40%	39%	39%	39%	41%
Ceftriaxone	23%	26%	23%	31%	38%	21%	18%	21%	16%	16%
Gentamicin	8%	11%	8%	12%	10%	13%	13%	11%	16%	22%
Nalidixic acid	4%	2%	4%	5%	4%	5%	8%	4%	6%	5%
Streptomycin	34%	40%	44%	45%	50%	50%	50%	45%	49%	51%
Tetracycline	51%	57%	51%	44%	52%	52%	51%	49%	57%	54%
Trimethoprim-sulfamethoxazole	10%	4%	12%	9%	10%	15%	15%	18%	21%	20%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 10 years, 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

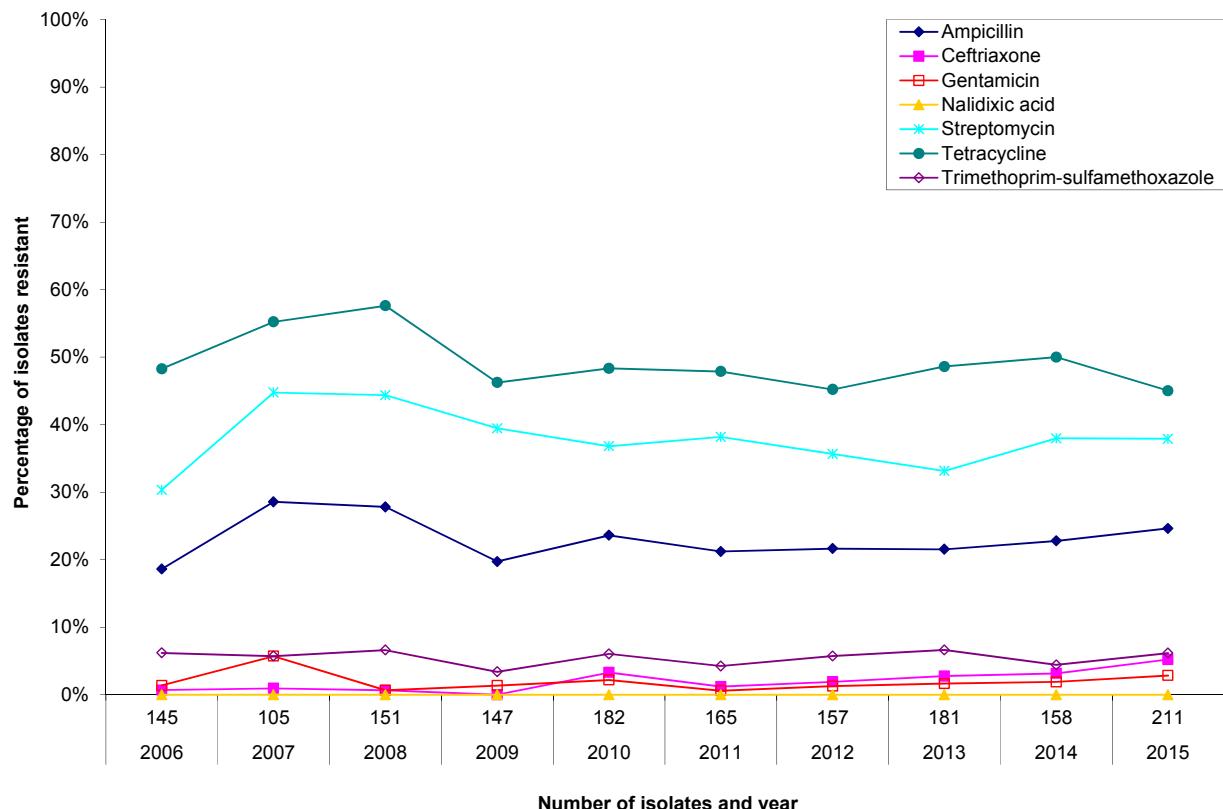
Figure 4. 23 Temporal variations in resistance of *Campylobacter* isolates from chickens, 2010–2015



Year	2010	2011	2012	2013	2014	2015
Number of isolates	111	117	155	138	188	143
Antimicrobial						
Azithromycin	6%	4%	6%	5%	5%	3%
Ciprofloxacin	4%	9%	7%	14%	11%	20%
Gentamicin	0%	0%	0%	0%	0%	0%
Telithromycin	4%	2%	5%	4%	2%	3%
Tetracycline	47%	39%	49%	39%	41%	46%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance years, the previous 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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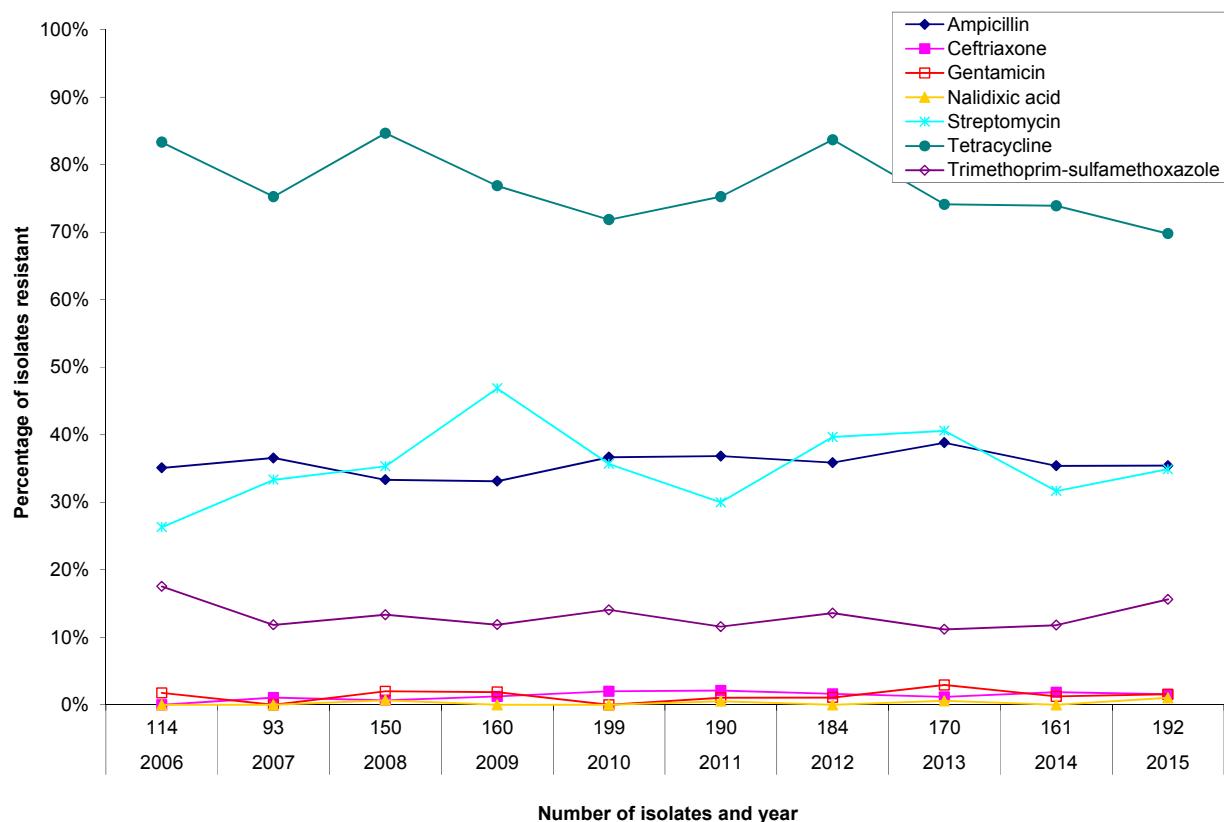
Figure 4. 24 Temporal variations in resistance of *Salmonella* isolates from pigs, 2006–2015

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	145	105	151	147	182	165	157	181	158	211
Antimicrobial										
Ampicillin	19%	29%	28%	20%	24%	21%	22%	22%	23%	25%
Ceftriaxone	1%	1%	1%	0%	3%	1%	2%	3%	3%	5%
Gentamicin	1%	6%	1%	1%	2%	1%	1%	2%	2%	3%
Nalidixic acid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptomycin	30%	45%	44%	39%	37%	38%	36%	33%	38%	38%
Tetracycline	48%	55%	58%	46%	48%	48%	45%	49%	50%	45%
Trimethoprim-sulfamethoxazole	6%	6%	7%	3%	6%	4%	6%	7%	4%	6%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years, the first year of surveillance, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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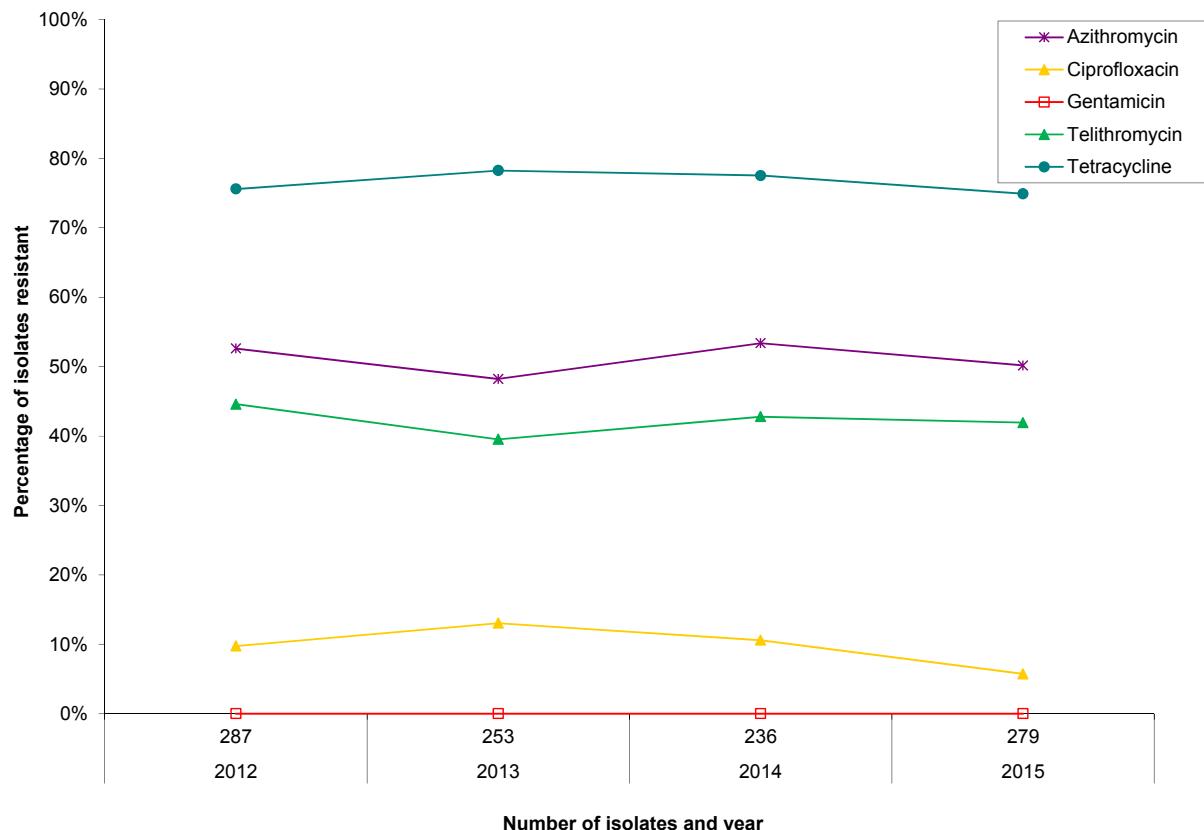
Figure 4. 25 Temporal variations in resistance of *Escherichia coli* isolates from pigs, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	114	93	150	160	199	190	184	170	161	192
Antimicrobial										
Ampicillin	35%	37%	33%	33%	37%	37%	36%	39%	35%	35%
Ceftriaxone	0%	1%	1%	1%	2%	2%	2%	1%	2%	2%
Gentamicin	2%	0%	2%	2%	0%	1%	1%	3%	1%	2%
Nalidixic acid	0%	0%	1%	0%	0%	1%	0%	1%	0%	1%
Streptomycin	26%	33%	35%	47%	36%	30%	40%	41%	32%	35%
Tetracycline	83%	75%	85%	77%	72%	75%	84%	74%	74%	70%
Trimethoprim-sulfamethoxazole	18%	12%	13%	12%	14%	12%	14%	11%	12%	16%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years, the first year of surveillance, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 26 Temporal variations in resistance of *Campylobacter* isolates from pigs, 2012–2015



Year	2012	2013	2014	2015
Number of isolates	287	253	236	279
Antimicrobial				
Azithromycin	53%	48%	53%	50%
Ciprofloxacin	10%	13%	11%	6%
Gentamicin	0%	0%	0%	0%
Telithromycin	45%	40%	43%	42%
Tetracycline	76%	78%	78%	75%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first year of surveillance and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

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RECOVERY RESULTS

Table 4. 19 Abattoir Surveillance recovery rates, 2002–2015

CIPARS Component/ Animal species	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted			
		<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>
Beef cattle	2002	97%	76/78	1%	3/78
	2003	97%	155/159	< 1 %	1/114
	2004	98%	167/170		
	2005	97%	122/126		66% 23/35
	2006	100%	150/150		36% 31/87
	2007	99%	188/190		39% 75/190
	2008	97%	176/182		71% ^a 129/182
	2009	94%	119/126		68% 86/126
	2010	97% ^b	77/79		53% ^b 37/70
	2011	99%	139/141		77% 108/141
	2012	99%	165/166		92% 152/166
	2013	100% ^b	59/59		92% ^b 54/59
	2014	99%	141/142		87% 123/142
	2015	98%	149/152		85% 129/152
Chickens	2002	100%	40/40	13%	25/195
	2003	97%	150/153	16%	126/803
	2004	99%	130/131	16%	142/893
	2005	99%	218/220	18%	200/1,103
	2006	100%	166/166	23%	187/824
	2007	99%	180/181	25%	204/808
	2008	99%	170/171	28%	234/851
	2009	100%	171/171	27%	230/851
	2010	99%	119/120	24%	142/599
	2011	99%	164/166	20%	140/701
	2012	100%	173/173	18% ^c	126/684
	2013	99%	171/172	16%	105/672
	2014	100%	170/170	15%	103/684
	2015	99%	179/181	18%	128/708
Pigs	2002	97%	38/39	27%	103/385
	2003	98%	153/155	28%	395/1,393
	2004	99%	142/143	38%	270/703
	2005	99%	163/164	42%	212/486
	2006	98%	115/117	40%	145/359
	2007	98%	93/95	36%	105/296
	2008	100%	150/150	44%	151/340
	2009	98%	160/163	45%	147/327
	2010	98%	199/203	44%	182/410
	2011	99%	190/191	43%	165/382
	2012	100%	184/184	42%	157/370
	2013	99%	166/168	52%	171/330
	2014	99%	161/162	49%	158/325
	2015	98%	192/195	55%	211/385

Grey-shaded areas indicate either: a) isolates recovered from sampling activities outside the scope of CIPARS routine (or "core") surveillance in the specified year (i.e., grey-shaded areas with data) or b) discontinuation or no surveillance activity (i.e., grey-shaded areas with no data).

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

^b In 2010 and 2013, the number of samples received from abattoir beef cattle was much lower than anticipated due to substantial drop in submissions related to unavoidable operational issues at 2 major participating abattoirs.

^c Decreased prevalence in chickens and one non-compliant plant (lack of sampling) resulted in a shortfall of *Salmonella* isolates from chickens.

FARM SURVEILLANCE

KEY FINDINGS

A summary of *Farm Surveillance* recovery rates for both broiler chickens and grower-finisher pigs are presented in Table 4. 29 and Table 4. 30.

BROILER CHICKENS^{33, 34}

SALMONELLA (n = 361)

Placement (n = 38)

When data from all provinces/regions were combined as a whole, the top 3 *Salmonella* serovars were Enteritidis, Kentucky, and Mbandaka (Table 4. 21). Three Heidelberg were isolated (Table 4. 21). Provincial differences in serovar distribution were noted with Enteritidis being the only serovar isolated in British Columbia (100%, 8/8) and the top serovar in the Prairies (27%, 3/11) (Table 4. 20). Heidelberg (43%, 3/7) was the most common serovar in Ontario and Kentucky was the most common (67%, 8/12) in Québec (Table 4. 20). Enteritidis was the top serovar detected from chick pads (38%, 11/29) (Table 4. 21); all Enteritidis isolates were susceptible to all antimicrobials tested (Table 4. 21).

No ciprofloxacin or nalidixic acid resistance was observed in any serovar (Table 4. 21).

Eight percent (3/38) of all the chick placement isolates were resistant to ceftriaxone and all other β-lactam antimicrobials (Table 4. 21). No isolates were resistant to 4 or more classes of antimicrobials.

Pre-harvest (n = 323)

When data from all provinces/regions were combined, the top 3 *Salmonella* serovars were Kentucky, Enteritidis, and Heidelberg (Table 4. 22). Regional differences in serovar distribution were observed with Kentucky (43%, 31/72) being the most common serovar in British Columbia, Enteritidis (16%, 13/84) in the Prairies, Heidelberg in Ontario (35%, 37/106) and Kentucky in Québec (77%, 47/61) (Table 4. 22).

None of the Enteritidis isolates were resistant to any antimicrobial tested (Table 4. 22).

There were 3 *Salmonella* isolates (less than 1%, 3/323) that were resistant to ciprofloxacin. Two of these isolates were from British Columbia (Kentucky isolates) and 1 was from the

³³ One hundred and thirty-five flocks from 136 different farm premises across 4 poultry producing provinces/regions (British Columbia, Prairies, Ontario, and Québec) were enrolled in 2015, 45 flocks (33%) were also sampled at chick placement.

³⁴ Proportion of resistant isolates presented in the key findings section may slightly differ from those presented in the figures/tables (percentages adjusted for clustering to account for multiple samples per flock). Please refer to both the tables depicting the number of antimicrobial classes and the temporal figures and supporting tables.

Prairies (1 Ohio isolate, a less-commonly occurring serovar) (Table 4. 24). Twenty-nine isolates (9%, 29/323) in total were resistant to nalidixic acid. These nalidixic acid resistant isolates also came from British Columbia (28 Kentucky) and the Prairies (1 Ohio; same isolate that was resistant to ciprofloxacin) (Table 4. 24). In British Columbia, nalidixic acid significantly increased from 5% in 2013 to 30% in 2015 (Figure 4. 29).

When data from all provinces/regions were combined, ceftriaxone resistance was 13% (Figure 4. 29), slightly increased compared to 2014 (12%); regionally, a marked increase in ceftriaxone resistance (not significant) was noted in British Columbia between 2014 (14%) and 2015 (32%) as a result of the change in serovar distribution in this province (i.e., predominantly Kentucky). A significant decrease in ceftriaxone resistance was observed between 2013 and 2015 in the Prairies (32% in 2013 and 1% in 2015) and Ontario (43% in 2013 and 8% in 2015) (Figure 4. 29).

ESCHERICHIA COLI (n = 725)³⁵

Placement (n = 186)

One isolate from the Prairies was resistant to ciprofloxacin. Across all provinces/regions 5 isolates were resistant to nalidixic acid, 3 from British Columbia, 1 from the Prairies and 1 from Ontario (Table 4. 23). No isolates were resistant to 6 or more classes of antimicrobials.

Overall, the proportion of isolates resistant to ceftriaxone significantly decreased from 39% in 2013 to 24% in 2015. Regionally, resistance to ceftriaxone significantly decreased between 2013 and 2015 in British Columbia (67% in 2013 and 21% in 2015) and the Prairies (68% in 2013 and 12% in 2015) (Figure 4. 28).

Resistance to gentamicin was higher in 2015 (38%) (Table 4. 23) compared to the previous years (30% in 2013 and 31% in 2014). A significant increase in resistance to gentamicin was noted in British Columbia (70%) and this level was the highest since 2013 in that province and in any province/region sampled (Figure 4. 28). Overall, a higher proportion of gentamicin-resistant isolates were recovered from chick pads (48%) compared to environmental samples (14%), suggestive that contamination and antimicrobial use (see Chapter 3—Antimicrobial Use in Animals) upstream of the production pyramid may be influencing this increase.

Pre-harvest (n = 539)

When data from all provinces/regions were combined, 2 isolates (less than 1%) were resistant to ciprofloxacin. One ciprofloxacin isolate was recovered from British Columbia and 1 from Québec. Thirty-three isolates (6%, 33/539), recovered across all provinces/regions were resistant to nalidixic acid (Table 4. 25). No isolates were resistant to 6 or more classes of antimicrobials.

Overall, resistance to ceftriaxone significantly decreased in 2015 (12% compared to the previous 2 years of surveillance (2013: 32%; 2014: 24%). Compared to 2013, decreased

³⁵ Consisted of normal avian gut, environmental commensals, and avian pathogenic *E. coli* responsible for yolk sacculitis and septicemic diseases. As in other components, isolates were not further characterized.

resistance was noted across all provinces/regions and was significant in British Columbia, Prairies and Ontario (Figure 4. 30).

Resistance to gentamicin slightly increased (not significant) from 17% in 2014 to 19% in 2015 (Table 4. 25); a significant increase was noted only in British Columbia from 8% in 2014 to 21% in 2015 (Figure 4. 30). Although no significant increase was noted, gentamicin resistance levels in Québec were consistently high in the last 3 years (2013: 23%; 2014: 28%; 2015: 29%) compared to other provinces/regions (Table 4. 25 and Figure 4. 30).

CAMPYLOBACTER (n = 117)

Placement (n = 0)

Campylobacter was not isolated from the chick placement samples because of well documented/reported challenges in recovering the organism from chicks or newly cleaned barn environment.

Pre-harvest (n = 117)

The prevalence of *Campylobacter* in 2015 was similar to the baseline surveillance year 2013 (20%). Resistance to nalidixic acid and ciprofloxacin increased from 9% in 2014 to 17% in 2015. The resistant isolates were collected in British Columbia (25%, 6/25), Prairies (2%, 1/46) and Ontario (33%, 13/36) (Table 4. 26). There were 14 (12%, 14/117) telithromycin-resistant isolates. All of these isolates came from the Prairies. Telithromycin-resistant isolates were not isolated from this region in the previous years. Twenty one azithromycin and erythromycin resistant isolates (18%, 21/117) were collected in total. These isolates were largely from the Prairies (14 isolates), Ontario (4 isolates) and Québec (3 isolates) (Table 4. 26). When data from all provinces/regions were combined, the proportion of azithromycin and erythromycin resistant isolates increased (not significant) compared to the previous year (Figure 4. 31).

Two *C. coli* isolates were resistant to 4 or more classes of antimicrobials.

GROWER-FINISHER PIGS

SALMONELLA (n = 121)

On a national basis, resistance levels remained relatively stable. The only significant difference was that tetracycline resistance was lower in 2015 (60%) than in 2014 (69%) (Figure 4. 32).

Regionally, there was more variation in the resistance data than on a national level. In the Prairies resistance to ampicillin in *Salmonella* significantly decreased from 53% in 2011 and 28% in 2014 to 5% in 2015. Alternatively, ampicillin resistance significantly increased in Ontario from 45% in 2011 and 39% in 2014 to 52% in 2015. Similarly, ampicillin resistance in Québec significantly increased from 10% in 2011 to 43% in 2015. In Ontario, resistance to tetracycline in *Salmonella* significantly decreased from its highest level of 91% in 2014 to 83% in 2015. However, in Québec resistance to tetracycline in *Salmonella* significantly increased to 77% in 2015 from 44% in 2011. Tetracycline resistance in *Salmonella* has been steadily rising

in Québec since 2011. Also, in Québec, streptomycin resistance significantly increased from 12% in 2011 to 66% in 2015. No other significant variations were detected in the regional analysis for *Salmonella* (Figure 4. 33).

No isolates were resistant to more than 5 classes of antimicrobials (Table 4. 27). One Derby isolate from the Prairies was resistant to 10 antimicrobials with the pattern ACSSuT-A2C-CRO-SXT. One Seftenberg isolate from Québec was resistant to 11 antimicrobials with the pattern ACSSuT-A2C-CRO-GEN-SXT.

ESCHERICHIA COLI (n = 500)

This is the first year since the start of the farm swine program that only 1 *E. coli* isolate per sample was collected and tested, rather than 3. This change therefore has resulted in a decrease in the total *E. coli* isolate numbers.

Nationally, tetracycline resistance was significantly lower in 2015 (67%) than in 2006 (79%), 2011 (77%) or 2014 (73%) (Figure 4. 34).

There was more variation at a regional level than a national level in antimicrobial resistance detected in *E. coli* but the changes were less dramatic than for *Salmonella*. In the Prairies there was a significant decrease in resistance to tetracycline between 2011 (63%) and 2015 (51%) and between 2014 (60%) and 2015 (51%). In Ontario, tetracycline resistance was significantly lower in 2015 (78%) than in 2011 (83%) or 2014 (85%). In Québec no significant differences were detected (Figure 4. 35).

One *E. coli* isolate from Alberta and 1 from Ontario was resistant to 9 antimicrobials and 4 and 5 antimicrobial classes respectively with the following patterns: A2C-AMP-CRO-STR-SSS-TET-SXT and ACSSuT-A2C-CRO. One *E. coli* isolate from the province Québec was resistant to 6 classes of antimicrobials with the pattern ACSSuT-AZM (Table 4. 28).

MULTICLASS RESISTANCE

Table 4. 20 Number of antimicrobial classes in resistance patterns of *Salmonella* from chicks and barn environment at placement by province/region, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial													
		0	1	2–3	4–5	6–7	GEN	STR	Aminoglycosides			β-lactams			Folate pathway inhibitors		Macrolides		Phenolics		Quinolones	
							AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL		TET			
British Columbia																						
Enteritidis	8 (100)	8																				
Total	8 (100)	8																				
Prairies																						
Enteritidis	3 (27.3)	3																				
Mbandaka	3 (27.3)	3																				
Anatum	2 (18.2)	2																				
Senftenberg	2 (18.2)	2																				
Braenderup	1 (9.0)	1																				
Total	11 (100)	11																				
Ontario																						
Heidelberg	3 (42.8)	2	1				1	1	1	1	1	1	1									
Indiana	2 (28.6)	2																				
Kentucky	2 (28.6)		2				2															
Total	7 (100)	4	3				3	1	1	1	1	1	1						2			
Québec																						
Kentucky	8 (66.7)		8				8	2	2	2	2	2	2						8			
Mbandaka	2 (16.7)		1	1				1											2			
Thompson	2 (16.7)	2																				
Total	12 (100)	2	1	9			8	3	2	2	2	2	2						10			
National																						
Enteritidis	11 (28.9)	11																				
Kentucky	10 (26.3)		10				10	2	2	2	2	2	2						10			
Mbandaka	5 (13.1)	3	1	1				1											2			
Heidelberg	3 (7.9)	2	1				1	1	1	1	1	1	1									
Anatum	2 (5.3)	2																				
Indiana	2 (5.3)	2																				
Senftenberg	2 (5.3)	2																				
Thompson	2 (5.3)	2																				
Braenderup	1 (2.6)	1																				
Total	38 (100)	25	1	12			11	4	3	3	3	3	3						12			

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 21 Number of antimicrobial classes in resistance patterns of *Salmonella* from chicks and barn environment at placement, 2015

Sample type / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial														
								Aminoglycosides			β-lactams			Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL		TET	
Chick pad																						
Enteritidis	11 (37.9)	11																				
Kentucky	9 (31.0)		9						9	2	2	2	2	2								9
Mbandaka	4 (13.8)	3	1																			1
Heidelberg	2 (6.9)	2																				
Thompson	2 (6.9)	2																				
Braenderup	1 (3.5)	1																				
Total	29 (100)	19	1	9					9	2	2	2	2	2								10
Environmental																						
Anatum	2 (22.2)	2																				
Indiana	2 (22.2)	2																				
Senftenberg	2 (22.2)	2																				
Heidelberg	1 (11.1)		1						1	1	1	1	1	1								
Kentucky	1 (11.1)		1						1													1
Mbandaka	1 (11.1)		1						1													1
Total	9 (100)	6	3						2	2	1	1	1	1								2
All sample types																						
Enteritidis	11 (28.9)	11																				
Kentucky	10 (26.3)		10						10	2	2	2	2	2								10
Mbandaka	5 (13.1)	3	1	1					1													2
Heidelberg	3 (7.9)	2	1						1	1	1	1	1	1								
Anatum	2 (5.3)	2																				
Indiana	2 (5.3)	2																				
Senftenberg	2 (5.3)	2																				
Thompson	2 (5.3)	2																				
Braenderup	1 (2.6)	1																				
Total	38 (100)	25	1	12					11	4	3	3	3	3								12

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 22. Number of antimicrobial classes in resistance patterns of *Escherichia coli* from chicks and barn environment at placement by province, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial													
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	Folate pathway inhibitors	Macrolides	Phenolics	Quinolones	Tetracyclines	
British Columbia	37 (19.9)	1	6	24	6		26	19	15	7	7	7	7	25	1	2		3	12		
Prairies	44 (23.7)	18	11	12	3		9	6	14	5	5	5	5	7			1	1	20		
Ontario	66 (35.5)	13	14	30	9		14	19	32	14	14	14	14	22	6		4	1	39		
Québec	39 (21.0)	5	4	9	21		22	22	23	16	16	16	16	28	7		8		31		
National	186 (100)	37	35	75	39		71	66	84	42	42	42	42	82	14	2	13	1	5	102	

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 23. Number of antimicrobial classes in resistance patterns of *Escherichia coli* from chicks and barn environment at placement, 2015

Sample type	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides		β-lactams				Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines				
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Chick pad	130 (69.9)	21	22	55	32	63	54	60	35	35	35	35	69	8	2	10	1	3	75	
Environmental	56 (30.1)	16	13	20	7	8	12	24	7	7	7	7	13	6			3	2	27	
Total	186 (100)	37	35	75	39	71	66	84	42	42	42	42	82	14	2	13	1	5	102	

Antimicrobial abbreviations are defined in the Appendix.

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

Table 4. 24. Number of antimicrobial classes in resistance patterns of *Salmonella* from chickens at pre-harvest, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides		β-Lactams				Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines				
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
British Columbia																				
Kentucky	31 (43.0)		6	25		1	31	26	26	26	24	26	1				2	28	31	
Enteritidis	29 (40.3)	29																		
Hadar	3 (4.2)		3					3	3	1									3	
Liverpool	3 (4.2)	3																		
Berta	2 (2.8)	2																		
Cubana	2 (2.8)	2																		
Less common serovars	2 (2.8)	2																		
Total	72 (100)	38	9	25		1	34	29	27	26	24	26	1				2	28	34	
Prairies																				
Enteritidis	13 (15.5)	13																		
Hadar	10 (11.9)		10					9	7										10	
Kentucky	10 (11.9)	10						10											10	
Thompson	10 (11.9)	10																		
Infantis	9 (10.7)	9																		
Typhimurium	8 (9.5)	8																		
Senftenberg	6 (7.1)	6																		
Braenderup	5 (6.0)	5																		
Mbandaka	4 (4.8)		3	1				1											4	
6:7:k:-	2 (2.4)	2																		
Schwarzengrund	2 (2.4)	2																		
Worthington	2 (2.4)		2					2											2	
Less common serovars	3 (3.6)	1	1	1				1	1	1							1	1	1	
Total	84 (100)	56	4	24			23	8	1								1	1	27	
Ontario																				
Heidelberg	37 (34.9)	27	7	3				1	8	7	8	8	8	2	2				2	
Mbandaka	27 (25.5)	24	3																3	
Kentucky	16 (15.0)	3	13					13											13	
Infantis	6 (5.7)	6																		
Indiana	4 (3.8)	3	1		1	1													1	
Kiambu	4 (3.8)	4																		
Liverpool	3 (2.8)	3																		
Less common serovars	9 (8.5)	7	1	1				1	1	1	1	1	1						2	
Total	106 (100)	77	11	18			1	15	9	8	9	9	9	4	2				21	
Québec																				
Kentucky	47 (77.0)	4	42	1		1	43	6	6	6	6	6	6	1					43	
Thompson	6 (9.8)	6																		
Hadar	4 (6.6)		4					4											4	
Rough:z6	2 (3.3)		2					2											2	
Less common serovars	2 (3.3)	1	1																1	
Total	61 (100)	11	1	48	1		1	49	6	6	6	6	6	1					50	
National																				
Kentucky	104 (32.2)	7	71	26		2	97	32	32	32	30	32	2				2	28	97	
Enteritidis	42 (13.0)	42																		
Heidelberg	39 (12.0)	28	7	4		2	9	7	9	8	8	2	2						3	
Mbandaka	32 (9.9)	24	7	1		1							1						8	
Thompson	18 (5.6)	18																		
Hadar	17 (5.3)		17				16	10	1										17	
Infantis	15 (4.6)	15																		
Senftenberg	9 (2.8)	9																		
Typhimurium	9 (2.8)	8	1				1	1	1	1	1	1							1	
Less common serovars	38 (11.8)	31	2	5		1	5						3				1	1	6	
Total	323 (100)	182	16	99	26		3	121	52	41	42	39	41	9	2		2	3	29	132

See corresponding footNotes on the next page.

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

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

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 25. Number of antimicrobial classes in resistance patterns of *Escherichia coli* from chickens at pre-harvest, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial															
									Aminoglycosides			β-lactams				Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL					
British Columbia	97 (18.0)	14	24	39	20		20	34	65	37	28	36	24	35	5		6	1	18				41	
Prairies	152 (28.2)	48	30	60	14		28	51	37	14	14	13	14	47	5		7		5				79	
Ontario	195 (36.2)	49	35	88	23		25	48	80	14	14	13	12	79	46			17		7			107	
Québec	95 (17.6)	6	12	57	20		28	53	41	10	9	11	8	64	34	1		13	1	3			64	
National	539 (100)	117	101	244	77		101	186	223	75	65	73	58	225	90	1	43	2	33			291		

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 26. Number of antimicrobial classes in resistance patterns of *Campylobacter* from chicken at pre-harvest, 2015

Province or region / species	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial												
		0	1	2-3	4-5	6-7	GEN	TEL	CLI	AZM	ERY	FLR	CIP	NAL	TET						
British Columbia																					
<i>Campylobacter jejuni</i>	25 (100)	8	11	6													6	6			17
Total	25 (100)	8	11	6													6	6			17
Prairies																					
<i>Campylobacter coli</i>	2 (4.3)					2			2		2		2								2
<i>Campylobacter jejuni</i>	44 (95.7)	14	17	13				12		12		12	12				1	1			18
Total	46 (100)	14	17	13	2			14		14		14	14				1	1			20
Ontario																					
<i>Campylobacter coli</i>	2 (5.6)					2											2	2			2
<i>Campylobacter jejuni</i>	34 (94.4)	10	13	11													4	4		11	11
Total	36 (100)	10	13	13													4	4		13	13
Québec																					
<i>Campylobacter jejuni</i>	10 (100)	4	4	2													3	3			5
Total	10 (100)	4	4	2													3	3			5
National																					
<i>Campylobacter coli</i>	4 (3.4)					2	2			2		2	2				2	2			4
<i>Campylobacter jejuni</i>	113 (96.6)	36	45	32				12		12		19	19				18	18			60
Total	117 (100)	36	45	34	2			14		14		21	21				20	20			64

Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 27. Number of antimicrobial classes in resistance patterns of *Salmonella* from pigs, 2015

Province or region / serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial																		
									Aminoglycosides			β-lactams				Folate pathway inhibitors			Macrolides			Phenolics		Quinolones		Tetracyclines	
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL		TET						
Prairies																											
Derby	9 (20.9)	4	4	1					5	1	1	1	1	1	5	1					1			5			
Infantis	8 (18.6)	8																									
Schwarzengrund	5 (11.6)	2	3						3															3			
Uganda	4 (9.3)	4																									
Agona	3 (7.0)	2	1																					1			
Bovismorbificans	3 (7.0)	3																									
Alachua	2 (4.7)	2																									
Typhimurium	2 (4.7)	1	1																					1			
California	1 (2.3)		1						1															1			
Give	1 (2.3)		1						1									1	1		1			1			
4,12:-e,n,z15	1 (2.3)		1																					1			
6,8:-	1 (2.3)		1																								
London	1 (2.3)	1																									
Ohio	1 (2.3)		1						1		1						1	1									
Putten	1 (2.3)	1																									
Total	43 (100)	29	2	10	2				10	2	1	2	1	1	12	3			2			13					
Ontario																											
4,[5],12:i:-	15 (34.9)	1	14						14	14														14			
Typhimurium	9 (20.9)	1	8						8	8														8			
Derby	5 (11.6)	5																						5			
Worthington	4 (9.3)	4																						4			
Livingstone	3 (7.0)	3																						3			
Ohio	3 (7.0)	1	2						2	2	2													2			
Schwarzengrund	2 (4.7)	2																									
Brandenburg	1 (2.3)	1																									
10,l,z13:-	1 (2.3)	1																									
Total	43 (100)	7	12	24	2	24	24																36				
Québec																											
Typhimurium	17 (48.6)	4	4	9					12	12							9	4	2	7				17			
Brandenburg	7 (20.0)	7																									
Derby	3 (8.6)		3						3									3						3			
4,[5],12:i:-	3 (8.6)		3						3	3									3					3			
Infantis	3 (8.6)	2	1						1															1			
4,12,l,v:-	1 (2.9)																										
Senftenberg	1 (2.9)		1						1	1	1	1	1	1	1	1	1	1	1					1			
Total	35 (100)	10	4	8	13	1	20	16	1	1	1	1	1	1	16	5	2	11			25						
National																											
Typhimurium	28 (23.1)	2	5	4	17				20	20							17	4	2	15				26			
4,[5],12:i:-	18 (14.9)	1		17					17	17														17			
Derby	17 (14.0)	4	5	7	1				8	1	1	1	1	1	1	8	1		1					13			
Infantis	11 (9.1)	10	1						1															1			
Brandenburg	8 (6.6)	8																									
Schwarzengrund	7 (5.8)	4	3						3															3			
Ohio	4 (3.3)	1	1	2					2	2	3		1				3	1						2			
Uganda	4 (3.3)	4																									
Worthington	4 (3.3)		4																					4			
Agona	3 (2.5)	2	1																					1			
Bovismorbificans	3 (2.5)	3																									
Livingstone	3 (2.5)	3																						3			
Less common serovars	11 (9.1)	7	1	1	2				1	3	1	1	1	1	1	3	2		2					4			
Total	121 (100)	46	18	18	39	3	54	42	2	3	2	2	2	52	8	2	21				74						

Antimicrobial abbreviations are defined in the Appendix.

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

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

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

Table 4. 28. Number of antimicrobial classes in resistance patterns of *Escherichia coli* from pigs, 2015

Province or region	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial												
		Aminoglycosides		β-Lactams				Folate pathway inhibitors		Macrolides		Phenicols		Quinolones		Tetracyclines				
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Prairies	228 (45.6)	80	56	66	26		1	56	48	1	2	1	2	70	16		36	1	116	
Ontario	149 (29.8)	23	33	62	31		3	50	60	3	3	3	3	57	22		35		117	
Québec	123 (24.6)	12	23	71	16	1	2	48	42	1	3	1	3	63	24	1	23		101	
National	500 (100)	115	112	199	73	1	6	154	150	5	8	5	8	190	62	1	94	1	334	

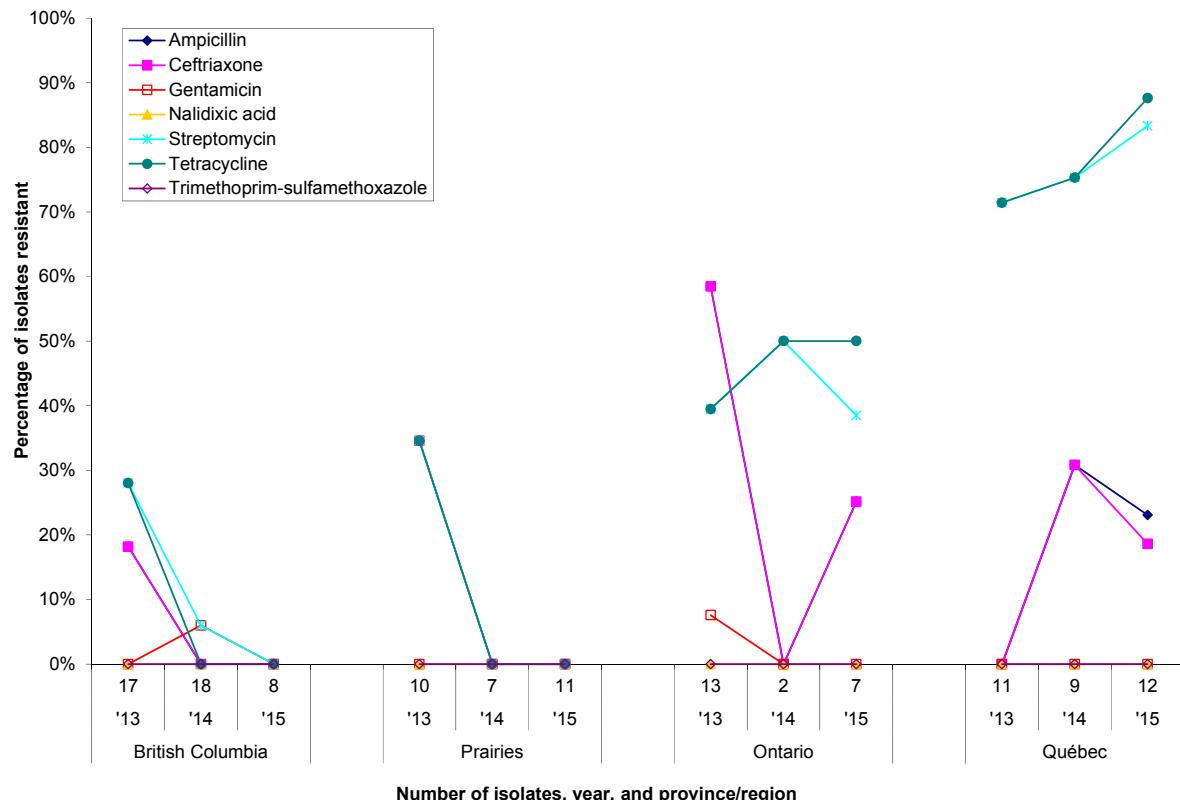
Antimicrobial abbreviations are defined in the Appendix.

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

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

TEMPORAL ANTIMICROBIAL RESISTANCE SUMMARY

Figure 4. 27 Temporal variations in resistance of *Salmonella* isolates from chicks and barn environment at placement by province/region, 2015

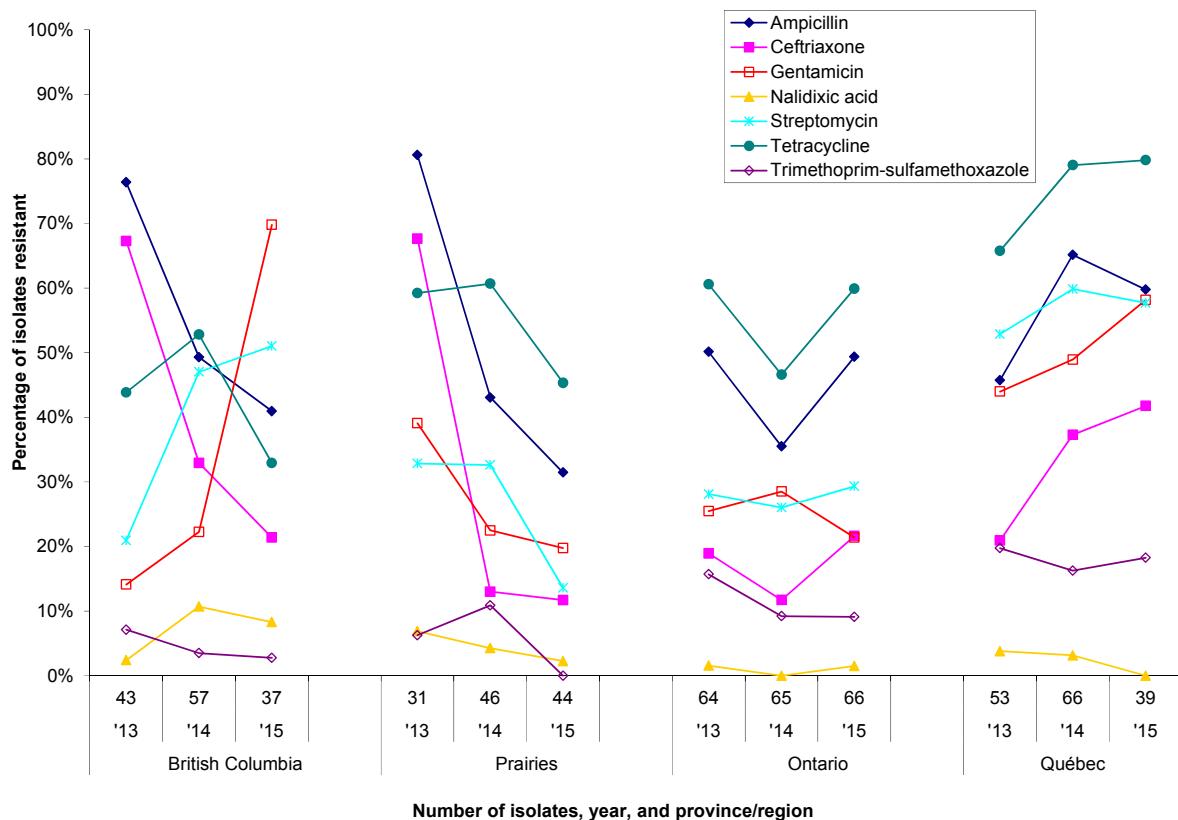


Province/region		British Columbia			Prairies			Ontario			Québec		
Year	Number of isolates	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
Antimicrobial													
Ampicillin		18%	0%	0%	35%	0%	0%	58%	0%	25%	0%	31%	23%
Ceftriaxone		18%	0%	0%	35%	0%	0%	58%	0%	25%	0%	31%	19%
Gentamicin		0%	6%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%
Nalidixic acid		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptomycin		28%	6%	0%	35%	0%	0%	39%	50%	38%	71%	75%	83%
Tetracycline		28%	0%	0%	35%	0%	0%	39%	50%	50%	71%	75%	88%
Trimethoprim-sulfamethoxazole		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

The proportion of resistant isolates for all antimicrobials was adjusted to account for multiple samples per flock. For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance year and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 4. 28. Temporal variations in resistance of *Escherichia coli* isolates from chicks and barn environment at placement by province/region, 2015

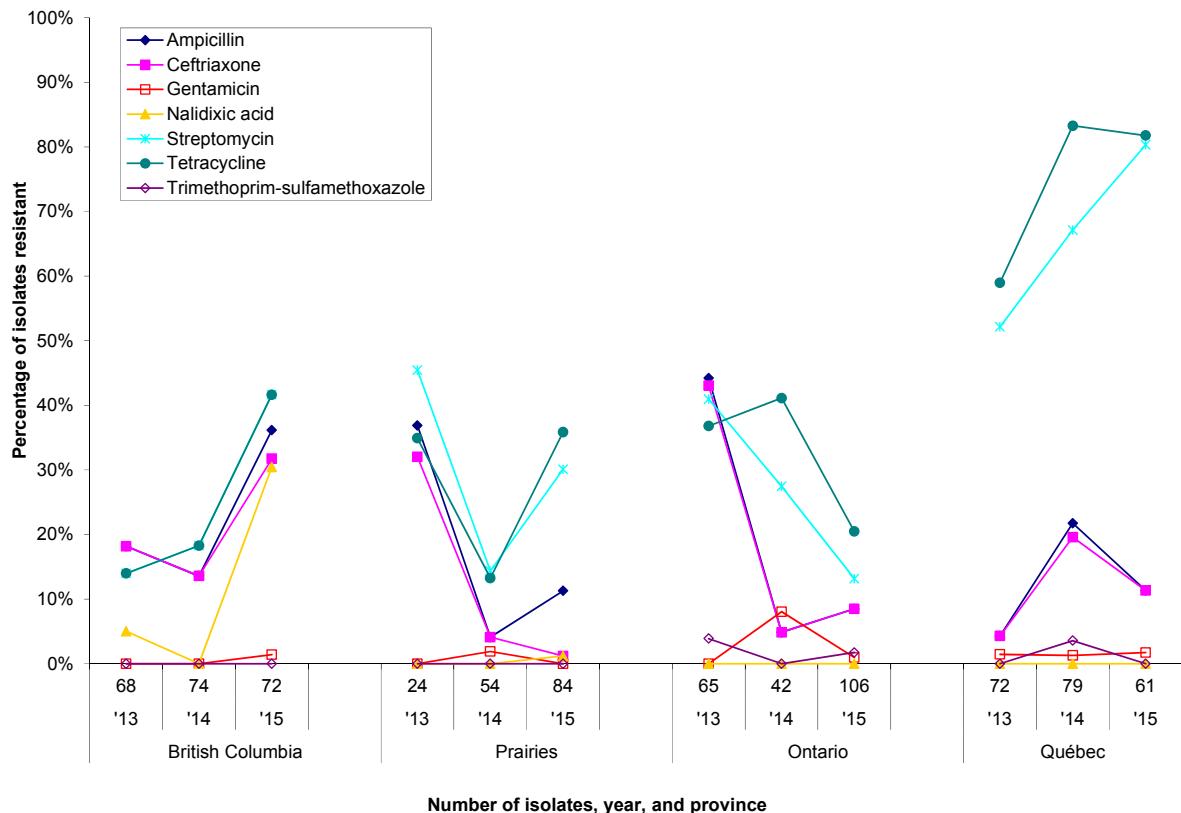


Province/region		British Columbia			Prairies			Ontario			Québec		
Year	Number of isolates	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
Antimicrobial													
Ampicillin		76%	49%	41%	81%	43%	31%	50%	36%	49%	46%	65%	60%
Ceftriaxone		67%	33%	21%	68%	13%	12%	19%	12%	22%	21%	37%	42%
Gentamicin		14%	22%	70%	39%	22%	20%	25%	28%	21%	44%	49%	58%
Nalidixic acid		2%	11%	8%	7%	4%	2%	2%	0%	2%	4%	3%	0%
Streptomycin		21%	47%	51%	33%	33%	14%	28%	26%	29%	53%	60%	58%
Tetracycline		44%	53%	33%	59%	61%	45%	61%	47%	60%	66%	79%	80%
Trimethoprim-sulfamethoxazole		7%	3%	3%	6%	11%	0%	16%	9%	9%	20%	16%	18%

The proportion of resistant isolates for all antimicrobials was adjusted to account for multiple samples per flock. For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance year and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 4. 29. Temporal variations in resistance of *Salmonella* isolates from chickens at pre-harvest by province/region, 2015

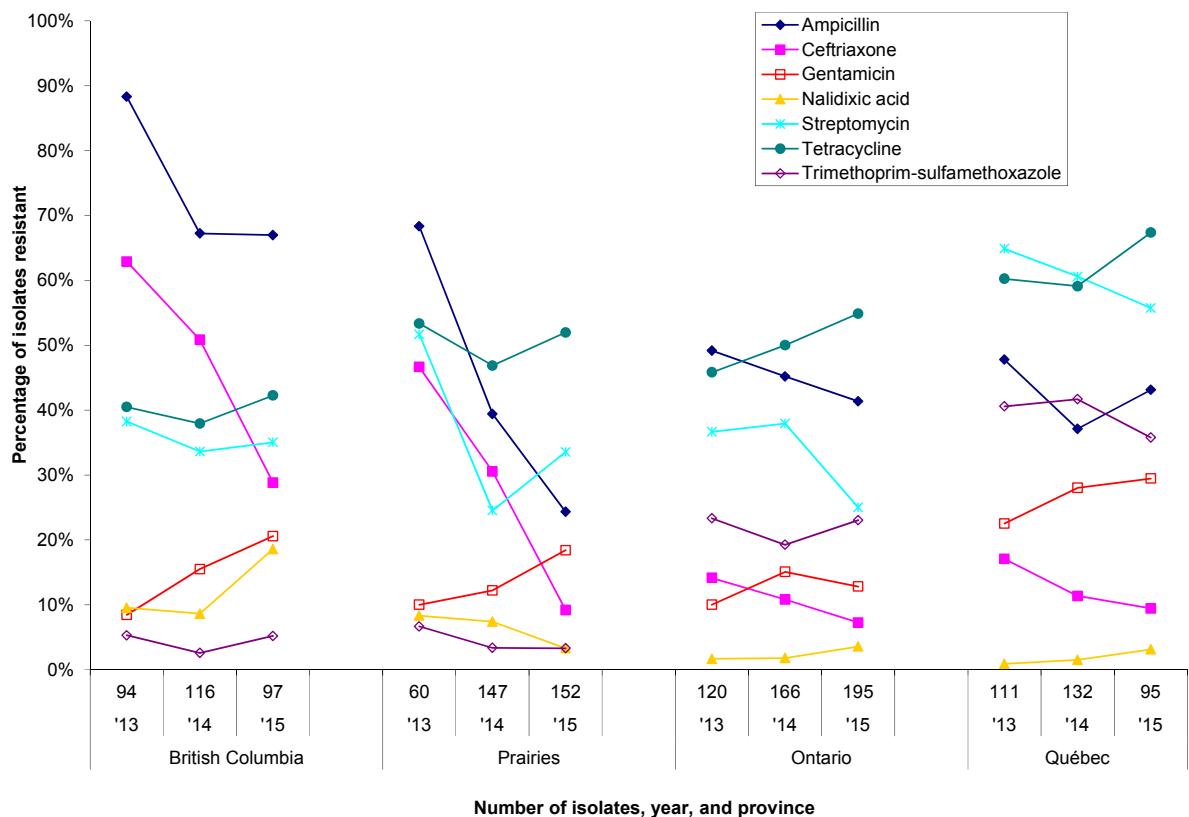


Province/region		British Columbia			Prairies			Ontario			Québec		
Year	Number of isolates	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
		68	74	72	24	54	84	65	42	106	72	79	61
Antimicrobial													
Ampicillin		18%	14%	36%	37%	4%	11%	44%	5%	8%	4%	22%	11%
Ceftriaxone		18%	14%	32%	32%	4%	1%	43%	5%	8%	4%	20%	11%
Gentamicin		0%	0%	1%	0%	2%	0%	0%	8%	1%	1%	1%	2%
Nalidixic acid		5%	0%	30%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Streptomycin		14%	18%	42%	45%	14%	30%	41%	27%	13%	52%	67%	80%
Tetracycline		14%	18%	42%	35%	13%	36%	37%	41%	20%	59%	83%	82%
Trimethoprim-sulfamethoxazole		0%	0%	0%	0%	0%	0%	4%	0%	2%	0%	4%	0%

The proportion of resistant isolates for all antimicrobials was adjusted to account for multiple samples per flock. For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance year and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Figure 4. 30. Temporal variations in resistance of *Escherichia coli* isolates from chickens at pre-harvest by province/region, 2015

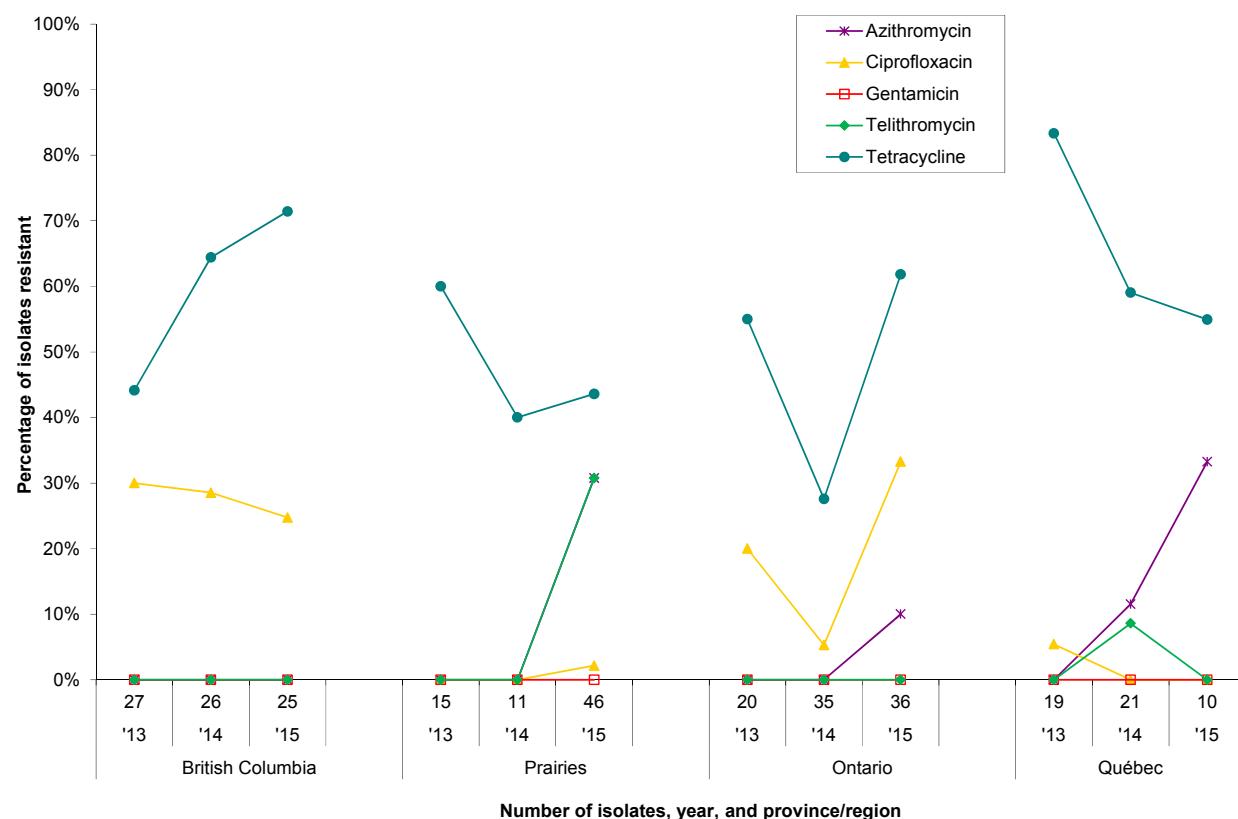


Province/region		British Columbia			Prairies			Ontario			Québec		
Year		'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
Number of isolates		94	116	97	60	147	152	120	166	195	111	132	95
Antimicrobial													
Ampicillin		88%	67%	67%	68%	39%	24%	49%	45%	41%	48%	37%	43%
Ceftriaxone		63%	51%	29%	47%	31%	9%	14%	11%	7%	17%	11%	9%
Gentamicin		8%	16%	21%	10%	12%	18%	10%	15%	13%	23%	28%	29%
Nalidixic acid		10%	9%	19%	8%	7%	3%	2%	2%	4%	1%	2%	3%
Streptomycin		38%	34%	35%	52%	25%	34%	37%	38%	25%	65%	61%	56%
Tetracycline		40%	38%	42%	53%	47%	52%	46%	50%	55%	60%	59%	67%
Trimethoprim-sulfamethoxazole		5%	3%	5%	7%	3%	3%	23%	19%	23%	41%	42%	36%

The proportion of resistant isolates for all antimicrobials was adjusted to account for multiple samples per flock. For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance year and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta and Saskatchewan.

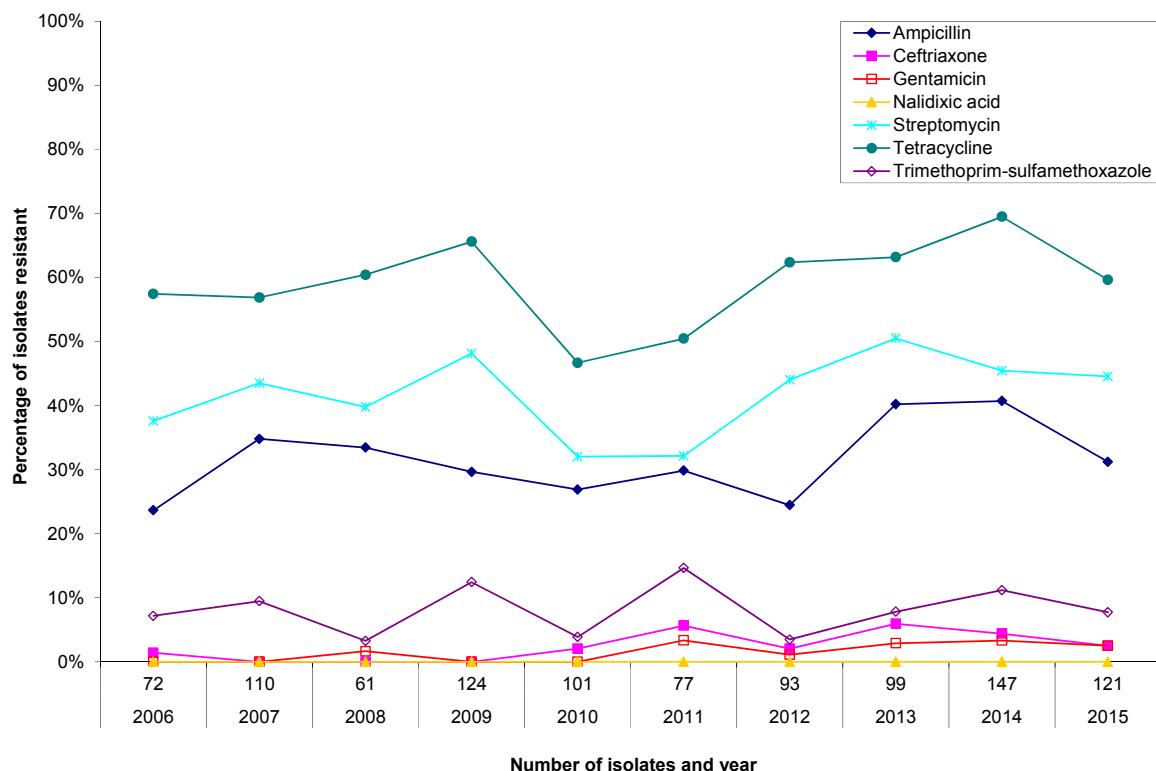
Figure 4. 31 Temporal variations in resistance of *Campylobacter* isolates from chickens at pre-harvest by province/region, 2015



Province/region	British Columbia			Prairies			Ontario			Québec		
Year	'13	'14	'15	'13	'14	'15	'13	'14	'15	'13	'14	'15
Number of isolates	27	26	25	15	11	46	20	35	36	19	21	10
Antimicrobial												
Azithromycin	0%	0%	0%	0%	0%	31%	0%	0%	10%	0%	12%	33%
Ciprofloxacin	30%	29%	25%	0%	0%	2%	20%	5%	33%	5%	0%	0%
Gentamicin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Telithromycin	0%	0%	0%	0%	0%	31%	0%	0%	0%	0%	9%	0%
Tetracycline	44%	64%	71%	60%	40%	44%	55%	28%	62%	83%	59%	55%

The proportion of resistant isolates for all antimicrobials was adjusted to account for multiple samples per flock. For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance year and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

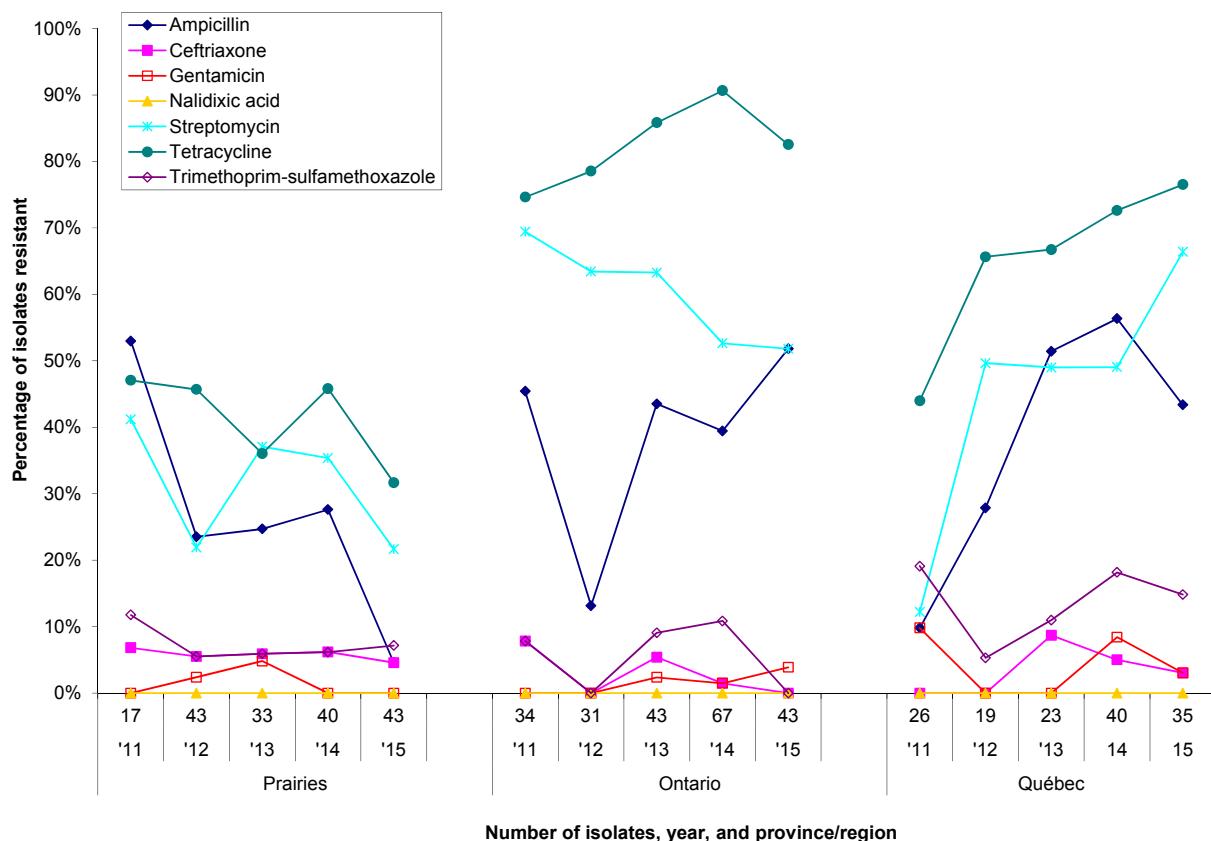
Figure 4. 32 Temporal variations in resistance of *Salmonella* isolates from grower-finisher pigs, 2006–2015



Year Number of isolates	2006 72	2007 110	2008 61	2009 124	2010 101	2011 77	2012 93	2013 99	2014 147	2015 121
Antimicrobial										
Ampicillin	24%	35%	33%	30%	27%	30%	24%	40%	41%	31%
Ceftriaxone	1%	0%	0%	0%	2%	6%	2%	6%	4%	2%
Gentamicin	0%	0%	2%	0%	0%	3%	1%	3%	3%	3%
Nalidixic acid	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptomycin	38%	44%	40%	48%	32%	32%	44%	50%	45%	45%
Tetracycline	57%	57%	60%	66%	47%	50%	62%	63%	69%	60%
Trimethoprim-sulfamethoxazole	7%	9%	3%	12%	4%	15%	3%	8%	11%	8%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance years, the previous 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 33 Temporal variations in resistance of *Salmonella* isolates from grower-finisher pigs, by province/region, 2011–2015

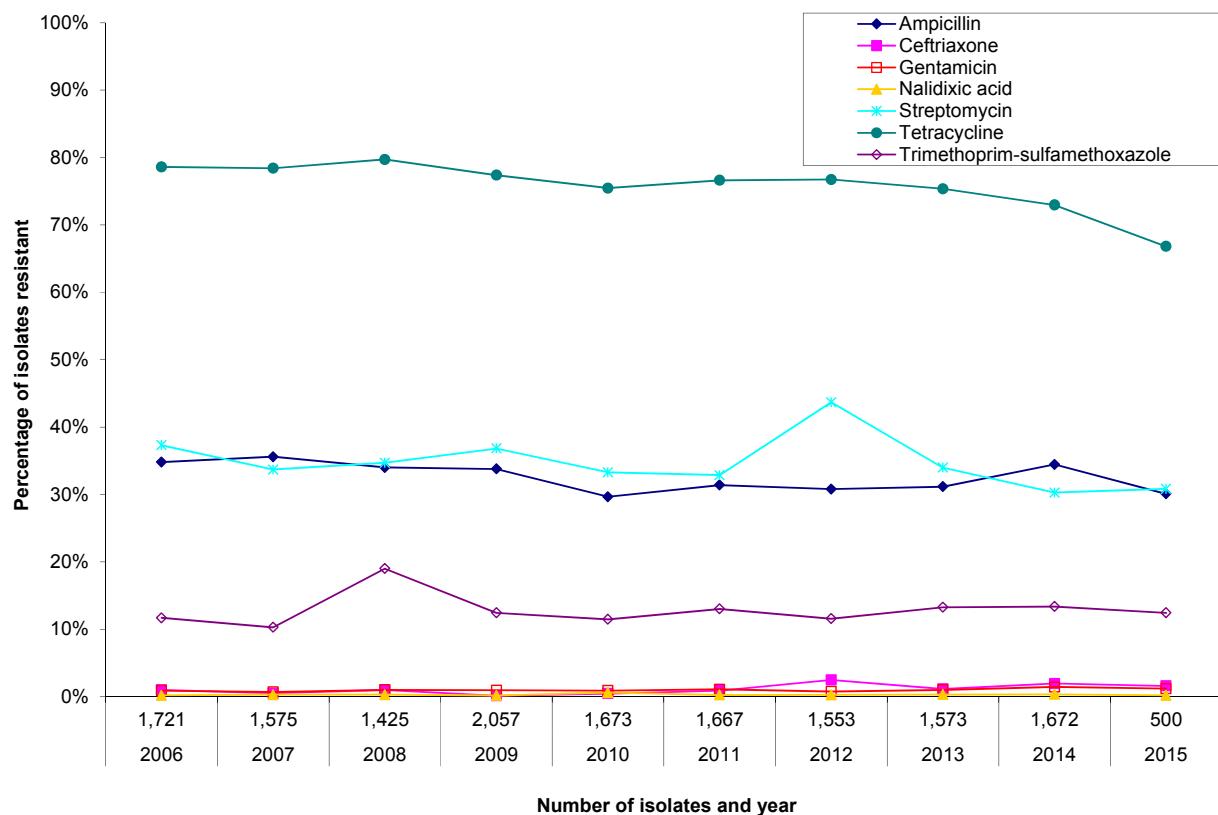


Province/region		Prairies					Ontario					Québec				
Year	Number of isolates	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15
Antimicrobial																
Ampicillin		53%	24%	25%	28%	5%	45%	13%	44%	39%	52%	10%	28%	51%	56%	43%
Ceftriaxone		7%	6%	6%	6%	5%	8%	0%	5%	1%	0%	0%	0%	9%	5%	3%
Gentamicin		0%	2%	5%	0%	0%	0%	0%	2%	1%	4%	10%	0%	0%	8%	3%
Nalidixic acid		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptomycin		41%	22%	37%	35%	22%	69%	63%	63%	53%	52%	12%	50%	49%	49%	66%
Tetracycline		47%	46%	36%	46%	32%	75%	79%	86%	91%	83%	44%	66%	67%	73%	77%
Trimethoprim-sulfamethoxazole		12%	6%	6%	6%	7%	8%	0%	9%	11%	0%	19%	5%	11%	18%	15%

For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

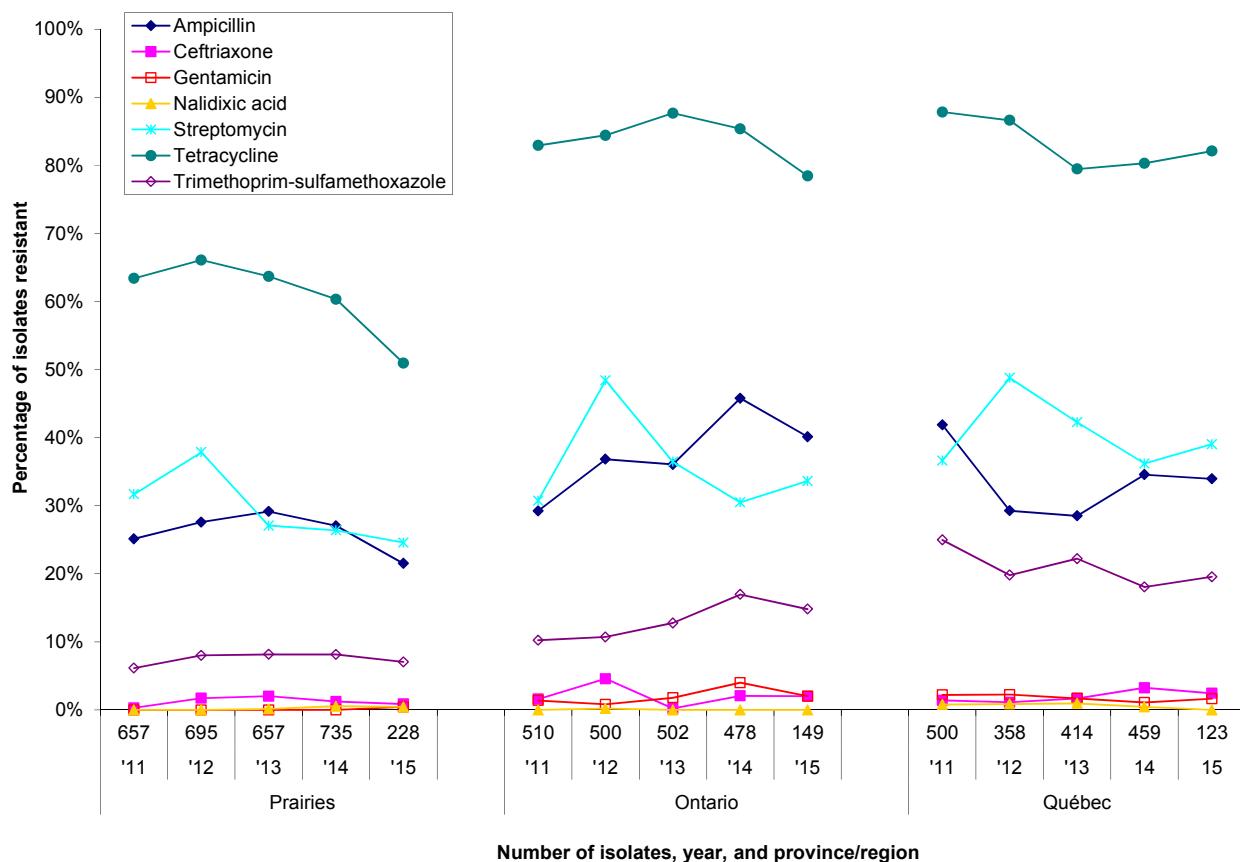
Figure 4. 34 Temporal variations in resistance of *Escherichia coli* isolates from grower-finisher pigs, 2006–2015



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of isolates	1,721	1,575	1,425	2,057	1,673	1,667	1,553	1,573	1,672	500
Antimicrobial										
Ampicillin	35%	36%	34%	34%	30%	31%	31%	31%	34%	30%
Ceftriaxone	1%	1%	1%	0%	0%	1%	2%	1%	2%	2%
Gentamicin	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Nalidixic acid	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
Streptomycin	37%	34%	35%	37%	33%	33%	44%	34%	30%	31%
Tetracycline	79%	78%	80%	77%	75%	77%	77%	75%	73%	67%
Trimethoprim-sulfamethoxazole	12%	10%	19%	12%	11%	13%	12%	13%	13%	12%

For the temporal analyses, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the first surveillance years, the previous 5 years, and the preceding surveillance year (grey areas). The presence of blue areas indicates significant differences ($P \leq 0.05$) for a given antimicrobial.

Figure 4. 35 Temporal variations in resistance of *Escherichia coli* isolates from grower-finisher pigs by province/region, 2011–2015



Province/region		Prairies					Ontario					Québec				
Year	Number of isolates	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15	'11	'12	'13	'14	'15
Antimicrobial		657	695	657	735	228	510	500	502	478	149	500	358	414	459	123
Ampicillin		25%	28%	29%	27%	22%	29%	37%	36%	46%	40%	42%	29%	28%	35%	34%
Ceftriaxone		0%	2%	2%	1%	1%	2%	5%	0%	2%	2%	1%	1%	2%	3%	2%
Gentamicin		0%	0%	0%	0%	0%	1%	1%	2%	4%	2%	2%	2%	1%	2%	2%
Nalidixic acid		0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%	1%	1%	0%	0%
Streptomycin		32%	38%	27%	26%	25%	31%	48%	36%	30%	34%	37%	49%	42%	36%	39%
Tetracycline		63%	66%	64%	60%	51%	83%	84%	88%	85%	78%	88%	87%	79%	80%	82%
Trimethoprim-sulfamethoxazole		6%	8%	8%	8%	7%	10%	11%	13%	17%	15%	25%	20%	22%	18%	20%

For the temporal analyses by province/region, the proportion (%) of isolates resistant to a specific antimicrobial over the current year has been compared to the proportion (%) of isolates resistant to the same antimicrobial during the previous 5 years and the preceding surveillance year (grey areas). The presence of blue areas indicate significant differences ($P \leq 0.05$) for a given province/region and antimicrobial.

The Prairies is a region including the provinces of Alberta, Saskatchewan, and Manitoba.

RECOVERY RESULTS

Table 4. 29 Farm Surveillance recovery rates in broiler chickens, regional and national, 2013–2015

CIPARS Component / Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted			
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>
Chickens (Chick placement)	British Columbia	2013	72%	43/60	28%	17/60
		2014	71%	57/80	23%	18/80
		2015	74%	37/50	16%	8/50
	Prairies	2013	89%	31/35	29%	10/35
		2014	82%	46/56	13%	7/56
		2015	80%	44/55	20%	11/55
	Ontario	2013	85%	64/75	17%	13/75
		2014	87%	65/75	3%	2/75
		2015	88%	66/75	9%	7/75
	Québec	2013	82%	53/65	17%	11/65
		2014	83%	66/80	11%	9/80
		2015	87%	39/45	27%	12/45
	National	2013	81%	191/235	22%	51/235
		2014	80%	234/291	12%	36/291
		2015	83%	186/225	17%	38/225
Chickens (Pre-harvest)	British Columbia	2013	98%	94/96	71%	68/96
		2014	100%	116/116	64%	74/116
		2015	97%	97/100	72%	72/100
	Prairies	2013	100%	60/60	40%	24/60
		2014	99%	147/148	36%	54/148
		2015	100%	152/152	55%	84/152
	Ontario	2013	100%	120/120	54%	65/120
		2014	99%	166/168	25%	42/168
		2015	99%	195/196	54%	106/196
	Québec	2013	99%	111/112	64%	72/112
		2014	100%	132/132	60%	79/132
		2015	99%	95/96	64%	61/96
	National	2013	99%	385/388	59%	229/388
		2014	99%	561/564	44%	249/564
		2015	99%	539/544	59%	323/544

Grey-shaded areas indicate either: a) isolates recovered from sampling activities outside the scope of CIPARS routine (or "core") surveillance in the specified year (i.e., grey-shaded areas with data) or b) discontinuation or no surveillance activity (i.e., grey-shaded areas with no data).

The Prairies is a region including the provinces of Alberta and Saskatchewan.

Table 4. 30. Farm Surveillance recovery rates in grower-finisher pigs, regional and national, 2006–2015

CIPARS Component/ Animal species	Province / region	Year	Percentage (%) of isolates recovered and number of isolates recovered / number of samples submitted			
			<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>
Pigs	Prairies	2012	100% 232/232	19% 43/232		
		2013	98% 224/228	14% 33/228		
		2014	99% 248/252	16% 40/252		
		2015	97% 228/234	18% 43/234		
	Ontario	2012	99% 167/168	18% 31/168		
		2013	100% 168/168	26% 43/168		
		2014	100% 162/162	41% 67/162		
		2015	99% 149/150	29% 43/150		
	Québec	2012	100% 120/120	16% 19/120		
		2013	100% 138/138	17% 23/138		
		2014	100% 156/156	26% 40/156		
		2015	98% 123/126	28% 35/126		
	National	2006	99% 459/462	20% 94/462		81% 374/462
		2007	100% 612/612	21% 136/612		81% 495/612
		2008	99% 481/486	13% 61/486		92% 448/486
		2009	99% 695/698	18% 124/698		97% 680/698
		2010	99% 566/569	18% 101/569		96% 545/569
		2011	100% 560/560	14% 77/560		
		2012	99% 519/520	18% 93/520		
		2013	99% 530/534	19% 99/534		
		2014	99% 566/570	26% 147/570		
		2015	98% 500/510	24% 121/510		

Grey-shaded areas indicate either: a) isolates recovered from sampling activities outside the scope of CIPARS routine (or "core") surveillance in the specified year (i.e., grey-shaded areas with data) or b) discontinuation or no surveillance activity (i.e., grey-shaded areas with no data).

The Prairies is a region including the provinces of Alberta, Saskatchewan and Manitoba.

SURVEILLANCE OF ANIMAL CLINICAL ISOLATES

KEY FINDINGS

CATTLE

SALMONELLA (n = 195)

Dublin was the most common serovar recovered from cattle (37%, 73/195). Twenty-two of these Dublin isolates (30%, 22/73) were resistant to 6 antimicrobial classes tested (resistant to all classes tested except the macrolides); all of these isolates were from Québec (n = 12) and Ontario (n = 10). Most Dublin isolates were from Québec (n = 36), Ontario (n = 17) and British Columbia (n = 15) (Table 4. 31).

The second most common serovar observed in cattle was Typhimurium (27%, 52/195). Fifteen Typhimurium isolates (29%) were resistant to 6 antimicrobial classes (resistant to all classes tested except the macrolides); all of these isolates were from Alberta. Twenty-three percent (12/52) of Typhimurium isolates were susceptible to all antimicrobials tested (Table 4. 31).

CHICKENS

SALMONELLA (n = 240)

Enteritidis was the most common serovar from chickens (53%, 128/240). All Enteritidis isolates from chickens were susceptible to all of the antimicrobials tested (Table 4. 32).

Kentucky was the second most common serovar from chickens (17%, 40/240). Only 1 isolate (3%) was susceptible to all antimicrobials tested; the others were resistant to 1 class (n = 5) or to 2-3 classes (n = 34) (Table 4. 32).

There were 12 Heidelberg isolates (5%, 12/240) from chickens in 2015. Ten Heidelberg (83%, 10/12) were susceptible to all antimicrobials tested; 1 isolate was resistant to only β-lactams and the other isolate was resistant to β-lactams and aminoglycosides (Table 4. 32).

Seventy percent (169/240) of all *Salmonella* isolates from chickens were susceptible to all antimicrobials tested (Table 4. 32).

PIGS

SALMONELLA (n = 378)

Typhimurium, 4,[5],12:i:-, and Derby were the most common serovars recovered from pigs in 2015, representing 38% (143/378), 16% (60/378) and 15% (57/378) of isolates, respectively (Table 4. 33).

Thirteen isolates from pigs were resistant to 6 antimicrobial classes (resistant to all classes tested except the quinolones). These included 3 Typhimurium isolates (1 from Manitoba, 2

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

from Québec), 3 4,[5],12:i:- (from Ontario), and 7 Ohio var. 14+ (from Manitoba). As in 2014, no quinolone resistance was observed in any clinical isolates from pigs (Table 4. 33).

TURKEYS

SALMONELLA (n = 112)

Senftenberg, Heidelberg, and Muenchen were the most common serovars recovered from turkeys in 2015, representing 24% (27/112), 19% (21/112) and 12% (13/112) of isolates, respectively (Table 4. 34).

Four isolates were resistant to 4 or more antimicrobial classes: 1 Senftenberg was resistant to 5 classes, 1 Agona was resistant to 4 classes, 1 *Salmonella* 4,[5],12:i:- isolate was resistant to 4 classes and another 1 *Salmonella* 4,[5],12:i:- isolate was resistant to 5 classes (Table 4. 34).

No resistance to quinolone or macrolide antimicrobials was observed in any isolates from turkeys in 2015 (Table 4. 34).

HORSES

SALMONELLA (n = 7)

One Heidelberg isolate was resistant to 5 classes (including the quinolones but not the β -lactams) and 1 Schwarzengrund isolate was resistant to 4 classes (Table 4. 35).

MULTICLASS RESISTANCE

Table 4. 31 Number of antimicrobial classes in resistance patterns of *Salmonella* from cattle, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial											
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL
Dublin	73 (37.4)	1	50	22	3	66	62	62	59	55	59	73				71	34		73
Typhimurium	52 (26.7)	12	25	15	13	40	40	11	10	11	10	40	21			39	5	15	40
4,[5],12:i:-	21 (10.8)	3	1	15	2	5	17	18	6	6	6	6	17	9		15		2	18
Cerro	8 (4.1)	8																	
Uganda	8 (4.1)	1	6	1	1	6							7	1		1			7
Heidelberg	5 (2.6)	3		2		2							2	2		2	2	2	2
Muenster	5 (2.6)	2	1	2		3	2						3	3		3			
Infantis	4 (2.1)	4																	
Kentucky	4 (2.1)	4																	
Less common serovars	15 (7.7)	10	1	4		5	3	2	2	2	2	5	1			3	1		5
Total	195 (100)	47	10	99	39	22	139	125	81	77	74	77	147	37		134	7	54	147

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 32 Number of antimicrobial classes in resistance patterns of *Salmonella* from chickens, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern						Number of isolates resistant by antimicrobial class and antimicrobial											
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL
Enteritidis	128 (53.3)	128																	
Kentucky	40 (16.7)	1	5	34			34		13	13	13	13	13						38
Heidelberg	12 (5.0)	10	1	1			1		2	2	2	2	2						
Hadar	9 (3.8)	1	8				8												9
Senftenberg	5 (2.1)	2	1	2		3	2	2											
Thompson	5 (2.1)	4		1			1	1					1						
Typhimurium	5 (2.1)	2	2	1			1	1					3			1			3
Less common serovars	36 (15.0)	22	7	7	3	7	4	4	4	4	4	4	4	2					8
Total	240 (100)	169	15	55	1	6	54	23	19	19	19	19	8	2		1			58

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 33 Number of antimicrobial classes in resistance patterns of *Salmonella* from pigs, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial											
		Aminoglycosides		β-Lactams					Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines			
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Typhimurium	143 (37.8)	14	7	10	109	3	13	112	118	1	1	1	120	26	5	103				128
4,[5],12:i:-	60 (15.9)	2	4	51	3		7	53	54	4	5	6	5	54	10	3	11			58
Derby	57 (15.1)	8	5	24	20		2	42	19	4	4	4	4	44	2		2			48
Infantis	25 (6.6)	17	1	4	3		2	4	3	3	3	3	3	6	2		6			8
Less common serovars	93 (24.6)	25	20	22	19	7	13	42	30	18	20	18	19	47	23	9	22			57
Total	378 (100)	66	37	60	202	13	37	253	224	30	32	32	31	271	63	17	144			299

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 34 Number of antimicrobial classes in resistance patterns of *Salmonella* from turkeys, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial											
		Aminoglycosides		β-Lactams					Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines			
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Senftenberg	27 (24.1)	5	9	12	1		15	14	12					1		1				8
Heidelberg	21 (18.8)	5	4	12			12	12	4	4	4	4	4	4	12					1
Muenchen	13 (11.6)	5	7	1			7								1					1
Bredeney	6 (5.4)	1	1	4			5	4	4	4	4	4	4	4	4					
Montevideo	6 (5.4)	1	5				6	3	5						1					
Kiambu	5 (4.5)	3	2						2	2	2	2	2	2						
Agona	4 (3.6)	2	1	1			1	2	1	1	1	1	1	2						1
Liverpool	4 (3.6)	1	3				3	2	1					2						1
Albany	3 (2.7)		3				3	3												3
Enteritidis	3 (2.7)	2	1				1	1	1											
4,[5],12:i:-	3 (2.7)		1	2			1	3	2					3	1					2
Less common serovars	17 (15.2)	5	3	9			5	10	5	1	1	1	1	3						6
Total	112 (100)	29	27	52	4		59	54	37	12	12	12	12	29	1					23

Antimicrobial abbreviations are defined in the Appendix.

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

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

Table 4. 35 Number of antimicrobial classes in resistance patterns of *Salmonella* from horses, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial											
		Aminoglycosides		β-Lactams					Folate pathway inhibitors		Macrolides		Phenolics		Quinolones		Tetracyclines			
		0	1	2-3	4-5	6-7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	AZM	CHL	CIP	NAL	TET
Newport	2 (28.6)	2																		
Thompson	2 (28.6)	2																		
Heidelberg	1 (14.3)			1			1						1	1		1	1	1	1	
Mbandaka var.14+	1 (14.3)	1																		
Schwarzengrund	1 (14.3)		1				1		1	1	1	1	1	1						1
Total	7 (100)	5	2				2	1	1	1	1	1	2	1		1	1	1	2	

Antimicrobial abbreviations are defined in the Appendix.

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

SURVEILLANCE OF FEED AND FEED INGREDIENTS

KEY FINDINGS

SALMONELLA (n = 21)

No isolates were resistant to any of the antimicrobials tested in 2015 (Table 4. 36).

MULTICLASS RESISTANCE

Table 4. 36 Number of antimicrobial classes in resistance patterns of *Salmonella* from feed and feed ingredients, 2015

Serovar	Number (%) of isolates	Number of isolates by number of antimicrobial classes in the resistance pattern							Number of isolates resistant by antimicrobial class and antimicrobial										
		0	1	2–3	4–5	6–7	GEN	STR	AMP	AMC	CRO	FOX	TIO	SSS	SXT	Folate pathway inhibitors	Macrolides	Phenolics	Quinolones
Senftenberg	11 (52.4)	11																	
Cubana	1 (4.8)	1																	
Enteritidis	1 (4.8)	1																	
Give	1 (4.8)	1																	
Infantis	1 (4.8)	1																	
Lille	1 (4.8)	1																	
Mbandaka	1 (4.8)	1																	
Montevideo	1 (4.8)	1																	
Muenster	1 (4.8)	1																	
Schwarzengrund	1 (4.8)	1																	
Tennessee var. 14+	1 (4.8)	1																	
Total	21 (100)	21																	

Antimicrobial abbreviations are defined in the Appendix.

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



CHAPTER 5—DESIGN AND METHODS

ANTIMICROBIAL USE

HUMAN SURVEILLANCE

Human antimicrobial use monitoring activities within the Public Health Agency of Canada (PHAC) are presented as part of the PHAC Human Antimicrobial Use Report 2015³⁶ and the Canadian Antimicrobial Resistance Surveillance System – Report 2016³⁷.

QUANTITIES OF ANTIMICROBIALS DISTRIBUTED FOR SALE FOR USE IN ANIMALS AND CROPS

As an estimate of antimicrobials used in animals, data on active ingredients distributed for sale were aggregated and provided to the Public Health Agency of Canada by the Canadian Animal Health Institute (CAHI). CAHI is the trade association representing the companies that manufacture and distribute drugs for administration to food (including fish), sporting, and companion animals in Canada. The association estimates that its members' sales represent over 90% of all sales of licensed animal pharmaceutical products in Canada³⁸. CAHI coordinates electronic collection of data from its members. Data collection and analysis are performed by a third party, Impact Vet³⁹. The CAHI data include information from 16 companies that manufacture antimicrobials products for use in animals in Canada, and 5 major wholesalers/distributors. The CAHI data on the distribution of antimicrobials for use in animals provide a context to interpret other data on antimicrobial use in animals generated through research and farm data collection. They also provide a means to estimate gross temporal changes in antimicrobials used in animals.

³⁶ Government of Canada. Human Antimicrobial Use Report, 2014. Government of Canada, Guelph, Ontario, 2015. Available at: <http://healthycanadians.gc.ca/publications/drugs-products-medicaments-produits/human-antimicrobial-use-2014-utilisation-antimicrobiens-humains/index-eng.php>. Accessed March 2017.

³⁷ Available at: <https://www.canada.ca/en/public-health/services/publications/drugs-health-products/canadian-antimicrobial-resistance-surveillance-system-report-2016.html>. Accessed March 2017.

³⁸ Canadian Animal Health Institute. Available at: www.cahi-icsa.ca/about. Accessed August 2016.

³⁹ Division of AgData Ltd. Available at: http://www.agdata.net/industry_platforms/canada/impact_vet. Accessed August 2016.

The level in the distribution chain that kilograms of active ingredients are reported to CIPARS is at the feed manufacturer/veterinary clinic/over-the-counter outlet/feed mill. Antimicrobial use was assigned to either production animal (inclusive of horses) or companion animal by the manufacturers according to label claim, and in the situation where mixed species was indicated on the label, the manufacturer assigned (estimated) the species as either companion animal or production animal.

These data do not represent actual antimicrobial use in a given year; rather, they reflect the volume of antimicrobials distributed by manufacturers and wholesalers. Distribution values should approximate amounts used, particularly when data from more than one year are included. However, when data from only one year are included, distribution values may vary from amounts actually used because of the time lag between distribution and actual use, as well as stockpiling of antimicrobials at various points in the distribution system. The sales data also do not account for drug wastage due to drug expiry.

The data do not include antimicrobials imported for personal use (own use importation—OUI) under the personal-use provision of the federal Food and Drugs Act and its Regulations, nor do they include imported active pharmaceutical ingredients (API), which are drugs imported in non-dosage form and compounded by a licensed pharmacist or veterinarian. The latest information from an Ipsos/Impact Vet study prepared for CAHI is that the lost opportunity value due to OUI and API was estimated to be 13% of total animal health product sales (*personal communication Jean Szkotnicki*). The CAHI data do not include prescriptions filled by pharmacists using human labeled drugs for antimicrobials used in companion animals. Hence, the CAHI data underestimate the true volume of antimicrobials used in animals in Canada. Also, the CAHI data do not capture what happens to the drugs after purchase; hence these data cannot provide information the actual antimicrobial use practices, such as dose, duration, reason for use, detailed species-specific information, or extra-label use.

The CAHI data include medicines sold directly to pharmacists that have a focus on dispensing for production medicine. It does not include antimicrobial agents moved from veterinarians to pharmacies and then subsequently dispensed by pharmacies. The latter distribution is captured with the veterinary clinic-level data.

CAHI provides the information in categories, with some antimicrobials not independently reported. This is based on a "3 company accounting rule" established by CAHI to comply with the European Union and the United States' anti-competition regulations. CAHI added in some cases a "90% rule" to be sure not to infringe the regulations in the United States. These accounting rules can result in changes to the categorization of specific antimicrobials over time. For 2015, the antimicrobials are categorized as per Table 5.1.

Table 5. 1 Canadian Animal Health Institute's aggregation of data on antimicrobial distributed for sale for use in animals, 2015

Antimicrobial class	Ingredient
Aminoglycosides	Amikacin, apramycin, dihydrostreptomycin, gentamicin, neomycin, spectinomycin, streptomycin
β-Lactams/penicillin	Amoxicillin, ampicillin, cloxicillin, penicillin, sulbactam, clavulanic acid
Cephalosporins	Ceftiofur, cepahpirin, cefovecin, cefaclor, cefadroxil
Fluoroquinolones	Enrofloxacin, difloxacin, marbofloxacin, orbifloxacin
Chemical coccidiostats	Amprolium, clopidol, decoquinate, diclazuril, narasin, nicarbazin, pyrimethamine, robenidine, zoalene
Ionophore coccidiostats	Lasalocid, maduramicin, monensin, salinomycin
Lincosamides	Clindamycin, lincomycin, pirlimycin
Macrolides	Erythromycin, gamithromycin, tilmicosan, tylosin, tulathromycin, tildipirosin, tyvalosin
Tetracyclines	Chlortetracycline, oxytetracycline, tetracycline
Trimethoprim and sulfonamides	Ormethoprim, trimethoprim, sulfabenzamide, sulfacetamide, sulfadiazine, sulfadimethoxine, sulfadoxine, sulfaguanidine, sulfamerazine, sulfamethazine, sulfanilamide, sulfaquinoxaline, sulfathiazole
Other antimicrobials	Avilamycin, bacitracins, bambermycin, chloramphenicol, florfenicol, nitrofurantoin, nitrofurazone, novobiocin, polymixin, tiamulin, virginiamycin

TEMPORAL FIGURES AND DATA TABLES FOR SIGNIFICANCE TESTING

As the CAHI data represent census information, there is no testing of statistical differences between years (i.e., the CAHI data are not data derived from samples). Any difference in findings between years should reflect a true difference in the quantities of antimicrobials distributed for sale by the member companies.

POPULATION CORRECTION UNIT

Changes in overall distribution of antimicrobials over time may reflect several things, including: true change in use practices, a change in the numbers or types of animals in the population (requiring antimicrobials), changes in disease prevalence necessitating antimicrobial use, and changes in the types of antimicrobials administered (with different potencies). As one way to adjust the sales data for the changing animal populations over time, a denominator accounting for the number of animals and their standardized weights (animal biomass) was applied. This denominator was based on the methodology currently in use by the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)⁴⁰.

ESVAC adjusts the sales data by a population correction unit (PCU) in which a PCU is a proxy for the animal biomass that is at risk of being treated with antimicrobials. It is a technical

⁴⁰ Sales of veterinary antimicrobial agents in 26 EU/EEA countries in 2012 (EMA/333921/2014). European Medicines Agency. European Surveillance of Veterinary Antimicrobial Consumption (ESVAC). Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Report/2014/10/WC500175671.pdf. Accessed August 2016.

measurement only; where 1 PCU = 1 kg of different categories of livestock and slaughtered animals. ESVAC methodology was applied to the greatest extent possible, however population information collected by Statistics Canada and Agriculture and Agri-Food Canada is different in structure somewhat from the data accessed by ESVAC (Eurostat and TRACES), hence direct comparisons of PCU's or mg/PCU with ESVAC participating country data should only be made with due caution.

The PCU is calculated by multiplying the numbers of livestock and slaughtered animals in each species/production state by the theoretical (standardized) weight at the most likely time of treatment^{41,42}.

Equation 5. 1 Formula for PCU calculation

PCU (kg) = number of animals * average weight of animal at treatment (kg)

$$\text{mg/PCU} = \frac{\text{Antimicrobials distributed (mg)}}{\text{PCU (kg)}}$$

National denominator data regarding the number of livestock and slaughtered animals for 2006 to 2015 were obtained from Statistics Canada, Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, the Canadian Animal Health Institute, and Equestrian Canada (formerly known as Equine Canada) websites and are detailed in Chapter 3. Note, that some websites periodically update their historic data, hence the data are considered as accurate as possible on the date accessed.

In 2016, CIPARS performed a review of the historical data and made updates to include the most recently restated data for each animal category. And thanks to the British Columbia Ministry of Agriculture, CIPARS included new stratifications of cattle slaughtered and exported pigs for feeding and slaughtered. CIPARS additionally applied the 1 kg weight for poultry imported and exported for the PCU_{ESVAC}, but maintained the weight categories based on the data collection structure available in Canada for the PCU_{CANADA}.

Detailed inclusions and exclusions for the PCU denominator:

As per ESVAC, exported animals were added to the PCU, whereas imported animals were subtracted, based on the ESVAC assumption that animals are treated in their country of origin. However, it was noted that in the Canadian context, this would vary depending upon the production stage that is crossing the border.

⁴¹ Sales of veterinary antimicrobial agents in 26 EU/EEA countries in 2012 (EMA/333921/2014). European Medicines Agency. European Surveillance of Veterinary Antimicrobial Consumption (ESVAC). Available at: http://www.ema.europa.eu/docs/en_GB/document_library/Report/2014/10/WC500175671.pdf. Accessed August 2016.

⁴² Trends in the sales of veterinary antimicrobial agents in nine European countries—Reporting period: 2005–2009. European Medicines Agency. European Surveillance of Veterinary Antimicrobial Consumption (ESVAC). Available at: www.ema.europa.eu/docs/en_GB/document_library/Report/2011/09/WC500112309.pdf. Accessed August 2016.

For the purposes of calculating the PCU, production animal species with the largest populations were included, using the same production classes as ESVAC (for the most part – dependent on the availability of the data), with the notable exception that we additionally included beef cows (not included by ESVAC).

Species currently excluded from our PCU calculations include game animals (e.g., moose), "pocket" companion animals (e.g., hamsters, guinea pigs, pet birds), reptiles, and amphibians.

For some production stages, import and export data for poultry are included in a different structure before and after 2009, based on the data available from Statistics Canada. The import and export of poultry for select weight categories were added, which is not included in the ESVAC methodology.

PROVINCIAL STRATIFICATION OF THE NUMERATOR AND DENOMINATOR

There may be subsequent distribution of antimicrobials across provincial borders after being distributed to the veterinary clinics (in particular the movement of medicated feed—for example, anecdotal information was that New Brunswick has a negligible feed-mill industry, they generally purchase their medicated feed from Québec), hence caution should be applied when interpreting the quantities of antimicrobials distributed for sale within each province. Provincial/regional calculations of PCU are pending further discussion.

OVERALL DISCUSSION OF STRENGTHS AND LIMITATIONS

The CAHI data provides a rough measure of antimicrobials distributed for sale for all animal species, including those not covered by CIPARS farm-level surveillance (with appropriate caveats regarding OUI/API). The PCU metric currently does not take into account the lifespan of the animal, which may affect the interpretation of the quantities of antimicrobials administered to animals. Also, use of a static standard weight may not reflect an industry shift in production affecting the average weights of animals treated, related to weather, trade, or other reasons. Measures of antimicrobial use as reported by broad categories and by a PCU denominator do not account for the individual potencies of the drugs that make up the category. For example, a decrease in the mg/PCU reported for a given year could potentially reflect a switch to using a more potent drug, as opposed to reflecting a decrease in the actual exposure of animals to antimicrobials. The CAHI data should be interpreted as one measure describing antimicrobials used in animals, strong caution should be applied with making inferences to any use practice for a particular animal species.

There have been several advances in detail of these data over the past recent years. Since 2011, the data have been stratified by province, since 2012 stratified by companion animal/production animal, and since 2013 stratified by route of administration.

QUANTITIES OF ANTIMICROBIALS DISTRIBUTED FOR SALE FOR USE ON CROPS

Health Canada's Pest Management Regulatory Agency (PMRA) collects annual Canadian sales data from all pesticide manufacturers. Sales information on antimicrobials registered as pesticides on food crops was kindly provided by PMRA to CIPARS. These data represent antimicrobials administered for the following reasons: fireblight on pome fruits (apples, pears, quince), caneberries and Saskatoon berries; blossom blast and bacterial canker on cherries; stem canker and bacterial spot on greenhouse and field fruiting vegetables (peppers, tomatoes, and eggplant); and walnut blight of walnuts. To protect confidential business information, the data are only presented in this report in combination with data from humans and animals.

FARM SURVEILLANCE

FARM QUESTIONNAIRE

BROILER CHICKENS

In the Broiler chicken *Farm Surveillance* component of CIPARS, sentinel farm data were collected through questionnaires administered by the poultry veterinarian (or designated practice staff) to the producer (or designated farm staff). The questionnaires collected information related to the hatchery and broiler farm levels. Veterinarians asked the producers for the chick delivery receipts, which contain information required to fill the hatchery-level portion of the questionnaire, such as breeder flock information including source origin (e.g., province of origin or imported); the age range of breeder flock source; whether the hatchery purchased the chicks as hatching eggs or chicks; the antimicrobials used and routes of administration, dosage, and primary reasons (treatment, prevention, high risk breeder flock source, producer request) and secondary reasons or by disease diagnosed (avian pathogenic *E. coli*, *Enterococcus cecorum*, *Salmonella* spp., *Staphylococcus* spp., early clostridial infections and other diseases), and; all vaccines administered *in ovo* or at the time of hatch. The veterinarians or a designated staff confirmed the information by calling the hatcheries. The farm-level portion of the questionnaire was completed by using feed delivery receipts, farm records, prescriptions and/or by asking the producer. Farm demographics information (e.g., quota period, age and estimated weight of birds at the time of visit, farm/barn/floor capacity), biosecurity and animal health information (i.e., vaccines administered at the farm level) were also obtained.

Producers/designated farm person were asked about antimicrobial use (AMU) via feed and water. Data were collected on each diet fed to the flock, including medicated and non-medicated feeds (non-medicated feeds did not contain antimicrobials). Information collected on each type of feed included the total days fed and age of the flocks at the start and end of each ration. Additional information was collected for diets containing antimicrobials: active ingredient(s), their concentration(s) in the feed, and the primary reason(s) for that AMU (growth promotion, disease prevention, or treatment). Secondary AMU reasons were captured if the primary use was for disease prevention or treatment; the list for secondary

reasons included the most commonly diagnosed conditions in broilers: yolk sacculitis, septicemia, musculoskeletal diseases, respiratory diseases, necrotic enteritis, coccidiosis, and other diseases (e.g., any non-bacterial etiology such as viral and metabolic).

Data collected on exposure to antimicrobials through water included active ingredient(s) in the drug(s) used, dosage (per liter of drinking water), start and end age of each water medication, the proportion of the flock exposed, and the reason(s) for use. The primary reasons and secondary reasons for prevention and treatment for AMU in water were similar to those described for feed AMU. The producers were also asked if a prescription was provided by a veterinarian whether the water medication was an over the counter purchase.

Based on the required components of the National Avian On-farm Biosecurity Standard⁴³, relevant questions were asked pertaining to the level of biosecurity. Questions on access management, animal health management and operational management were included. Data on flock health status (i.e., diagnosis of the most common bacterial and viral diseases), and on vaccine administration from the time of chick placement onwards were also collected.

GROWER-FINISHER PIGS

In the grower-finisher's *Farm Surveillance* component of CIPARS, sentinel farm data were collected through questionnaires administered by the herd veterinarian (or designated staff) to the producer (or designated farm staff). The questionnaires included sections requesting information on antimicrobial use (AMU), herd demographics and animal health.

Questions pertaining to the number of pigs in the population of interest differed by management system: continuous-flow or all-in-all-out. All-in-all-out management is a production system whereby animals are moved into and out of facilities in distinct groups. By preventing the commingling of groups, the intention is to reduce the spread of diseases. Facilities are normally cleaned and disinfected thoroughly between groups of animals. This type of management is generally by room or by barn. In continuous-flow operations, animals are continually being removed and added.

The AMU questionnaire was designed to collect data for groups of pigs in the grower-finisher production phase. No data on individual pigs were collected. Six pens representative of this population were selected for the collection of fecal specimens for bacterial culture and antimicrobial susceptibility testing. Thus, in herds with all-in-all-out management, the population of interest included all pigs that entered and exited the barn in the same group as the sampled pigs. The population of interest in herds with continuous-flow management was the pigs that entered the grower-finisher unit with the sampled pigs.

Herd owners/managers were asked about AMU via feed, water, and injections. Data were collected on each diet fed to the specified group of pigs, including medicated and non-medicated feeds (i.e., feeds did not contain antimicrobials). Information collected on each type of feed administered during the grow-finish period included the average number of

⁴³ Government of Canada. Animal biosecurity: National avian on-farm biosecurity standard. Available at: www.inspection.gc.ca/DAM/DAM-animals-animaux/STAGING/texte/terr_biosec_avian_standard_1375192173847_eng.pdf. Accessed September 2014.

weeks each ration was fed and the associated start and end pig weights. Additional information was collected for diets (rations) containing antimicrobials: active antimicrobial ingredient(s), their concentration(s) in the feed, and the primary reason(s) for that AMU (either growth promotion, disease prevention, or treatment). Under the primary reasons for AMU, disease prevention or treatment, respondents could choose any of the following secondary reasons for use in feed: respiratory disease, enteric disease, lameness or other diseases. The proportion of pigs fed each diet was also captured.

Data collected on exposure to antimicrobials through water or injection included active ingredient(s) of the drug(s) used, the reason(s) for use and the proportion of pigs exposed. The primary reasons for AMU in water included: disease prevention and disease treatment with associated secondary reasons for use being respiratory disease, enteric disease, lameness or other diseases. Only disease treatment reasons were collected for AMU administered by injection. The number of pigs exposed to AMU by water or injection was captured as categorical data with ranges of 1–25%, 26–50%, 51–75% or 76–100% of the pigs. No AMU data were collected for any production phase prior to the grower-finisher phase. Any data regarding AMU in pigs weighing less than 15 kg (33 lb) were excluded because this weight was considered below the industry standard for grower-finisher pigs.

DATA ANALYSIS

Data were entered into a PostGreSQL Database and descriptive statistics were obtained with commercially available software⁴⁴.

BROILER CHICKENS

Antimicrobial exposures from the hatching stage to the end of growth or pre-harvest sampling stage (≥ 30 days) were summarized for each flock. An exposure was defined as any reported use of an active ingredient by a given route of administration. Data were reported as exposure to an active ingredient by a given route of administration, as well as by exposure to an active ingredient by any administration route. These exposures were summarized by antimicrobial class.

Estimates of feed intake were based on simple regression and integral calculus. Feed consumption estimates from the 2014 Ross 308 and 708 performance objectives, the most recent Cobb 500 and 700 Broiler Performance and Nutrition Supplement manuals, and feed company standards (Wallenstein Feeds [Revised March 2016] and Nutreco-Shur Gain [updated estimates from Nutreco received October, 2016]) were loaded into Microsoft™ Excel. From these data, the cumulative feed consumption was calculated using the average of feeding standards for the 2 most common broiler strains and the standards developed by

⁴⁴ Microsoft Excel® 2003 and Microsoft Access® 2003, Microsoft Corp., Redmond, WA, USA; SAS® 9.1, SAS Institute Inc., Cary, NC, USA.

feeding companies (i.e., non-strain specific)^{45,46,47,48} for as-hatched broilers (i.e., males and females combined). A plot of feed consumption in grams per bird per day was created.

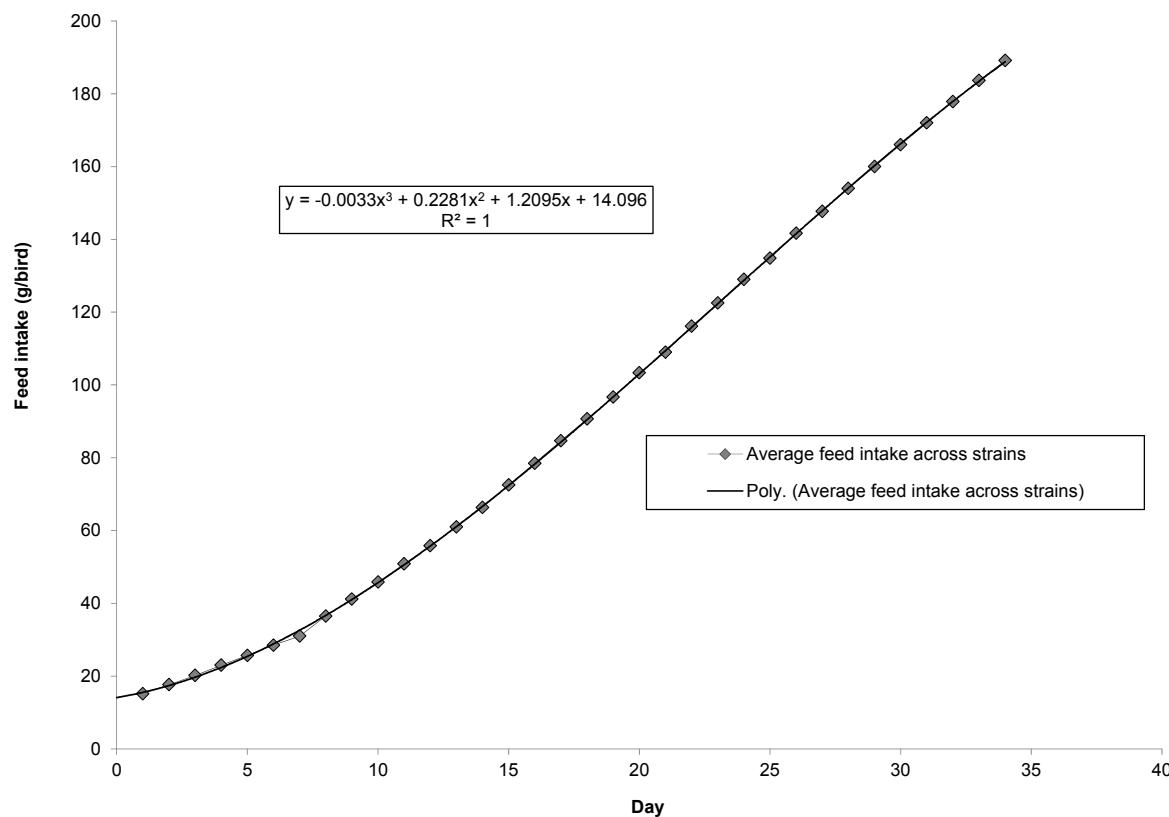
From the broiler chicken survey the start and end age of the birds was available for each ration. Since the end day of one ration was the start day of the next an algorithm was used to prevent overlapping days for each subsequent ration. Regression parameters were calculated within Microsoft™ Excel by using the plotted feed intake curve. A minimum R-square value of more than 0.99 was required to be considered a good fit therefore to obtain the best fitting regression values the feeding curve was divided into 3 segments. Feed consumption calculations based on the regression line in Figure 5. 1 were used if the age of the birds when they started or finished the ration was less or equal to 21 days (i.e., equivalent to brooding and early grow-out period). The regression line in Figure 5. 3 was used if the age of the birds when they started or finished the ration was equal or more than 35 days of age (i.e., equivalent to finisher phase or extended grow-out period in roasters). All other age ranges had feed consumption based on the regression line depicted in Figure 5. 2 (i.e., grow-out period). From the regression coefficients feed consumption could then be calculated using integral calculus.

⁴⁵ Cobb-Vantress, Inc. Products: Cobb 500™. Broiler Performance and Nutrition Supplement. Revised December 2012. http://www.cobb-vantress.com/docs/default-source/cobb-500-guides/Cobb500_Broiler_Performance_And_Nutrition_Supplement.pdf. Accessed September 2016.

⁴⁶ Cobb-Vantress, Inc. Products: Cobb 700™. Broiler Performance and Nutrition Supplement. Revised July 2015. Available at: http://www.cobb-vantress.com/docs/default-source/cobb-700-guides/cobb700_broiler_performance_nutrition_supplement_english9294AABB12037B70EE475E39.pdf. Accessed September 2016.

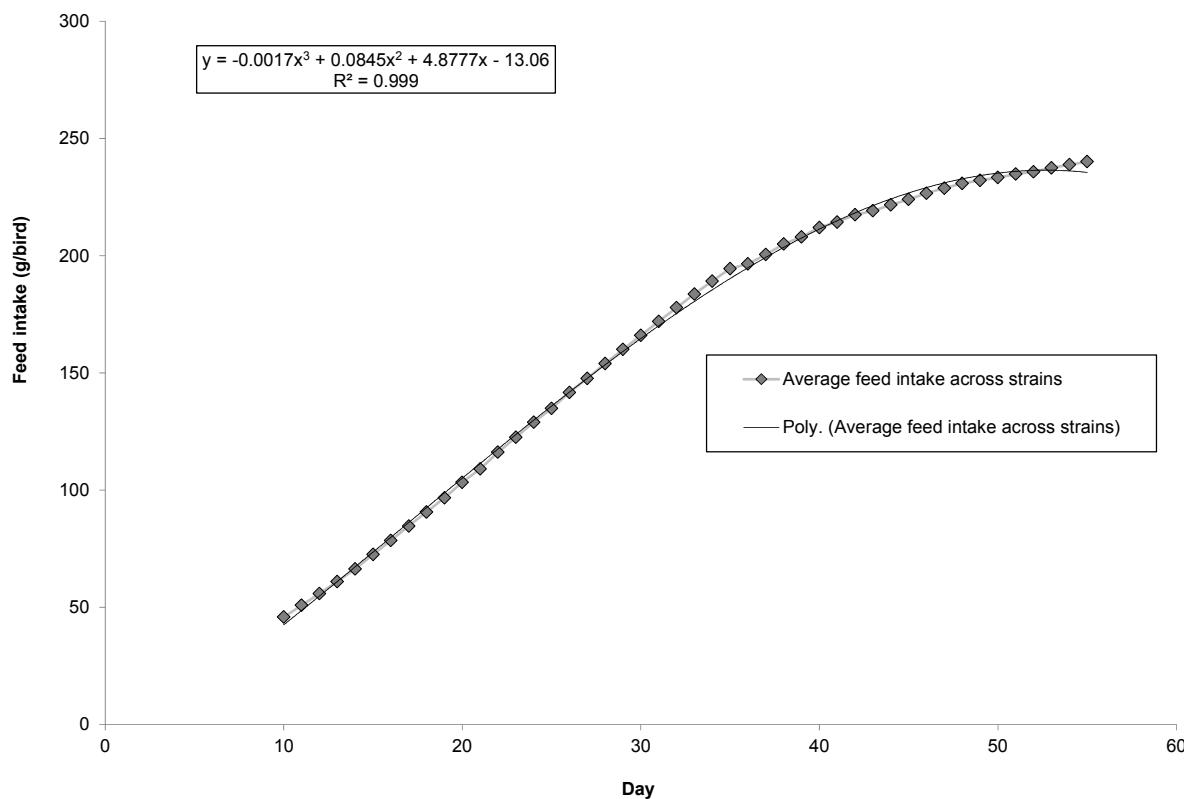
⁴⁷ Aviagen. Ross 308. Available at: http://en.aviagen.com/assets/Tech_Center/Ross_Broiler/Ross-308-Broiler-PO-2014-EN.pdf. Accessed August 2016.

⁴⁸ Aviagen. Ross 708. Available at: http://en.aviagen.com/assets/Tech_Center/Ross_Broiler/Ross-708-Broiler-PO-2014-EN.pdf. Accessed August 2016.

Figure 5. 1 Segment one daily feed intake (g/bird) based on common broiler chicken breeds

Feed intake (g/day) are based on the average consumption of the common broiler chicken breeds raised in Canada with growth curves derived from the feed standards/guidelines and the fitted polynomial regression line generated in Microsoft™ Excel.

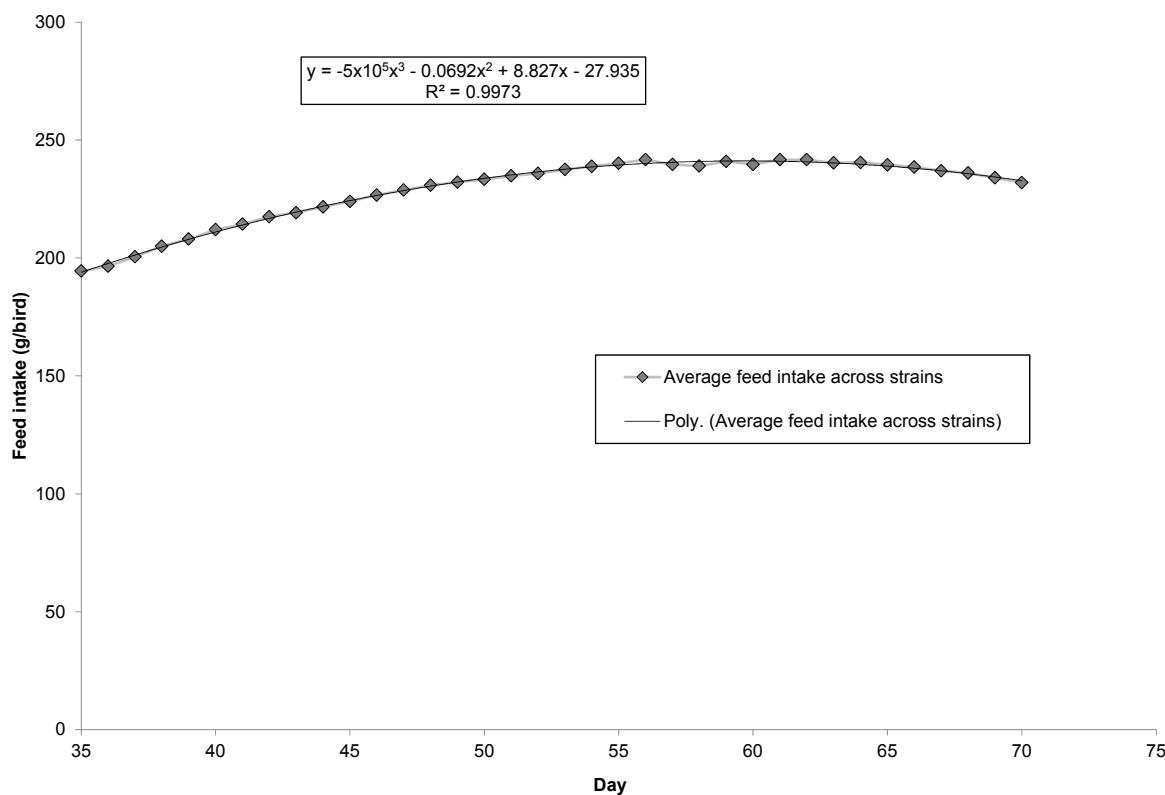
Poly. = polynomial.

Figure 5. 2 Segment two daily feed intake (g/bird) based on common broiler chicken breeds

Feed intake (g/day) are based on the average consumption of common broiler chicken breeds raised in Canada with growth curves derived from the feed standards/guidelines and the fitted polynomial regression line generated in Microsoft™ Excel.

Poly. = polynomial.

Figure 5. 3 Segment three daily feed intake (g/bird) based on common broiler chicken breeds



Feed intake (g/day) are based on the average consumption of the common broiler chicken breeds raised in Canada with growth curves derived from the feed standards/guidelines and the fitted polynomial regression line generated in Microsoft™ Excel.

Poly. = polynomial.

The area under the curve for each regression equation provided an estimate of feed consumption. The equation for each segment of the curve was as follows; where the corresponding "β" values came from the regression line for each segment of the curve and the ages (t) for each treatment came from the questionnaire (as entered).

Equation 5. 2 Formula for the first and second segment polynomial of feed consumption

$$\beta_0 t + \beta_1 t^2 / 2.0 + \beta_2 t^3 / 3.0 + \beta_3 t^4 / 4.0$$

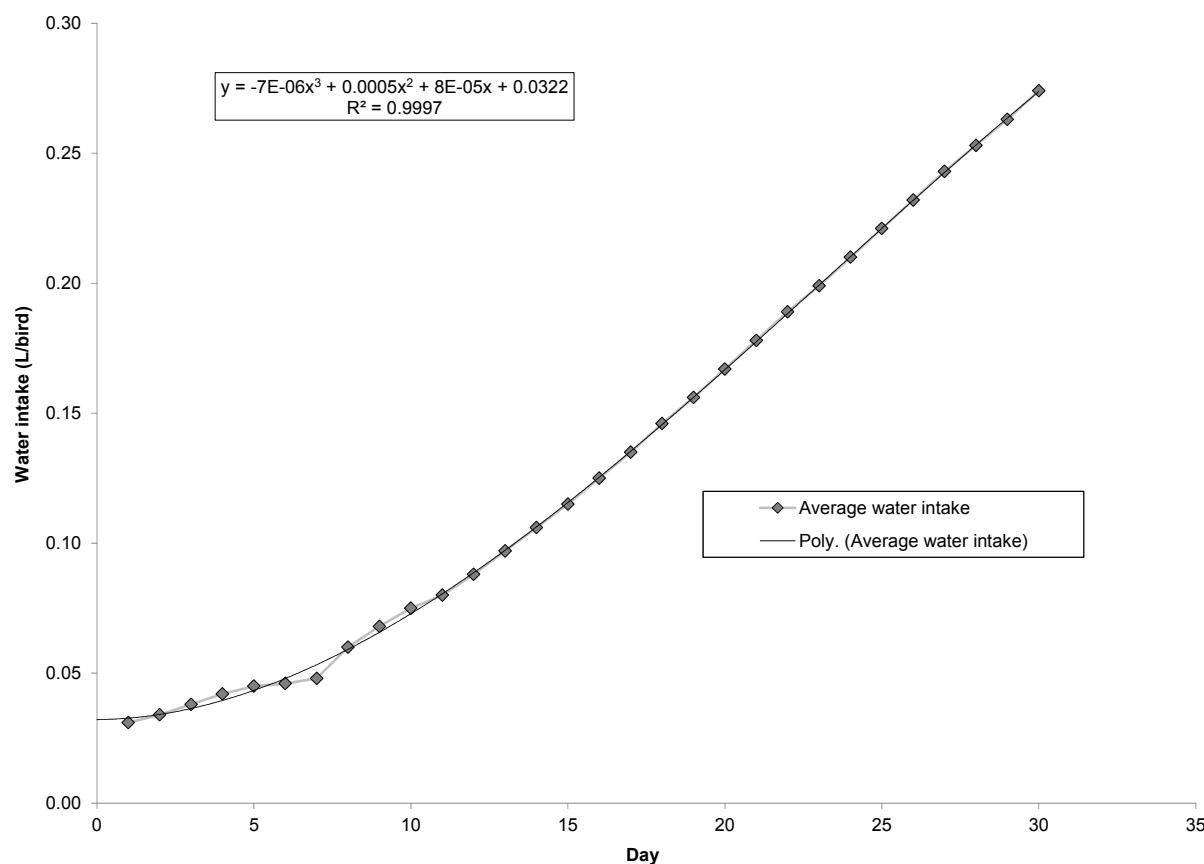
Equation 5. 3 Formula for the third segment polynomial of feed consumption

$$\beta_0 t \beta_1 t^2 / 2.0 + \beta_2 t^3 / 3.0$$

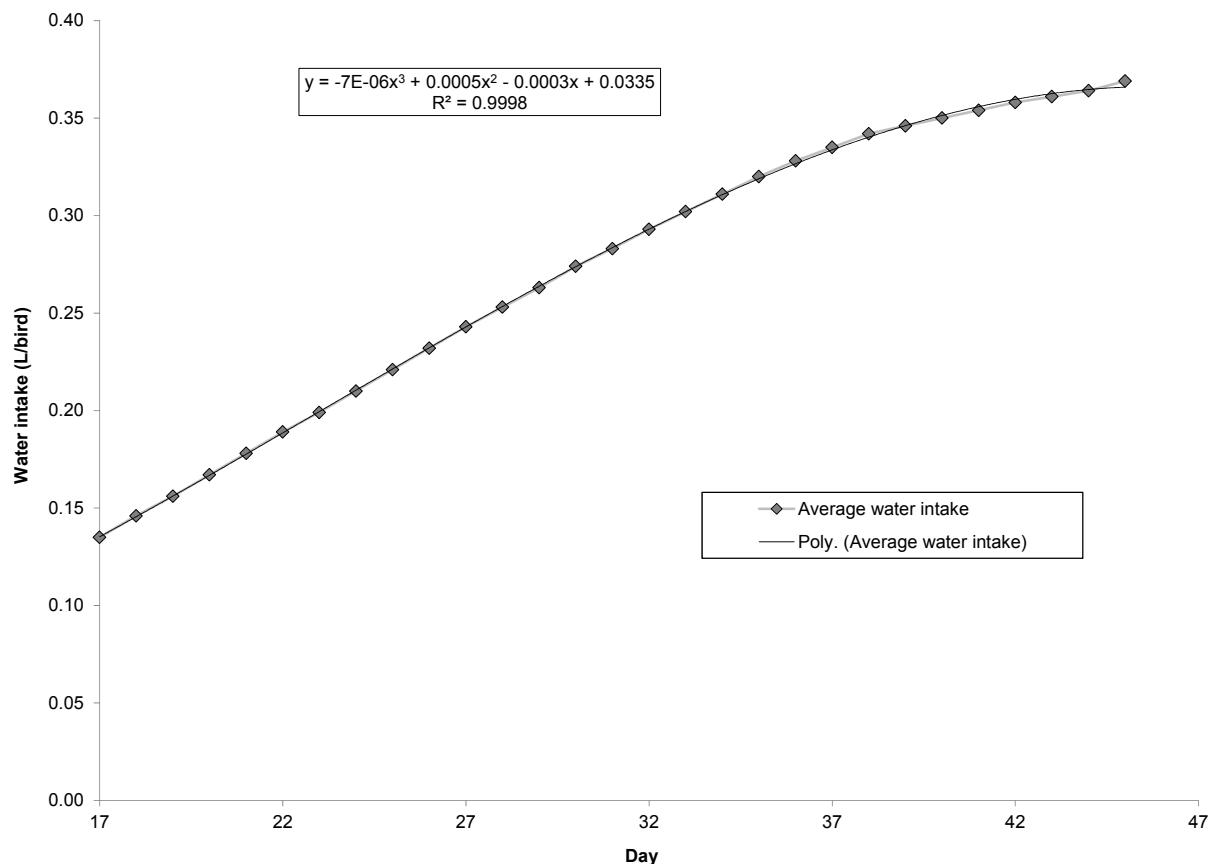
Using PLpgSQL code within the PostGreSQL database, for the applicable regression line, 2 integrals were calculated, the lower integral where "t" was the start age and the upper integral where "t" was the end age. The difference between the upper and lower integral yielded the estimate of feed intake in grams per bird. Feed consumption was converted from grams to tonnes and multiplied by the number of birds at risk (i.e., total birds minus half of the cumulative mortality rate at the time of sampling) to provide an estimate of total tonnes fed for each ration. The number of birds reported were the total birds delivered in the poultry unit of concern (barn or floor) including the 2% allowance provided by the hatchery. This value was then utilized to calculate the grams of antimicrobial consumed per ration and incorporated into the quantitative analysis.

Broiler chickens—water consumption calculations: estimates of water consumption were based on simple regression and integral calculus. Water consumption estimates were uploaded into Microsoft™ Excel from the Nutreco Canada Inc. (Revised April 4, 2011) daily water consumption chart and a plot of intake in liters/bird/day was created.

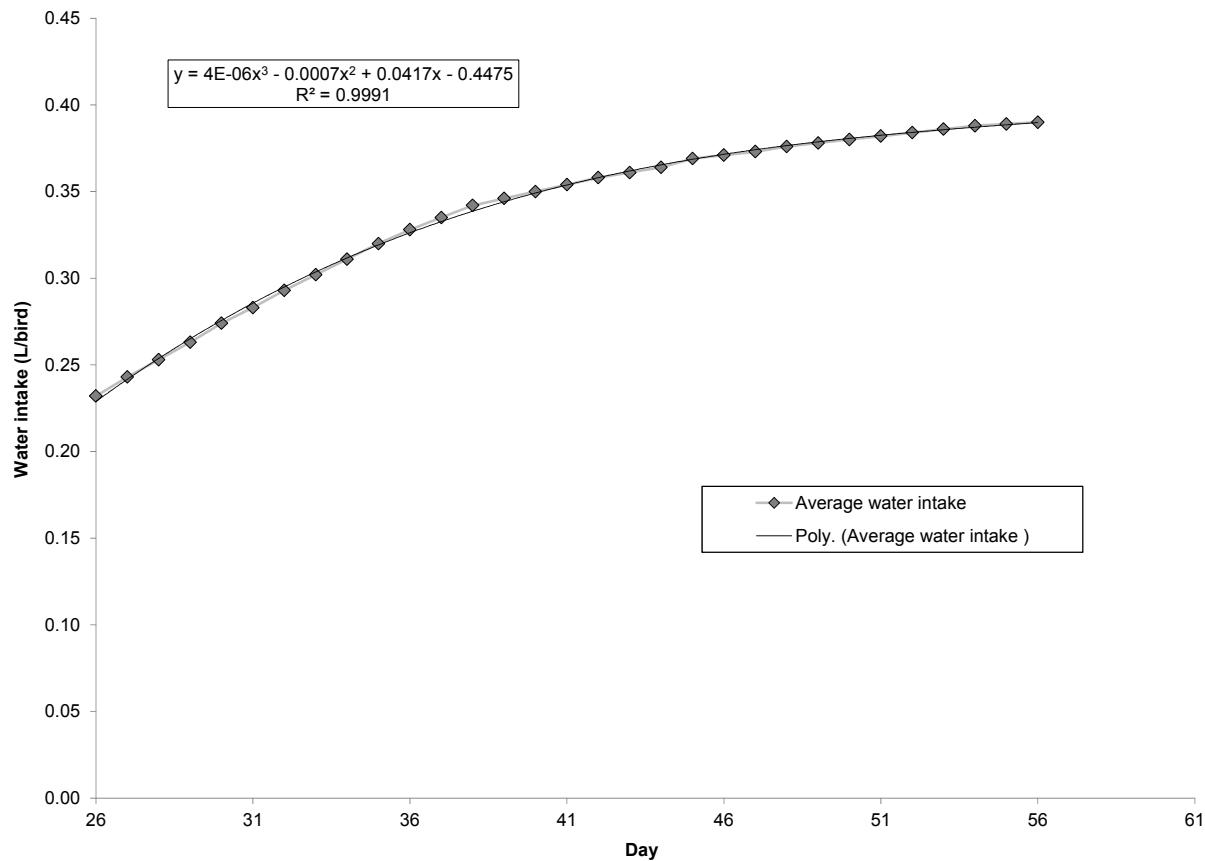
From the broiler chicken survey, the start and end age of the birds was available for each water treatment. An algorithm was used to prevent any possible overlapping of age in days for consecutive water treatments with different antimicrobials in the same flock. Regression parameters were calculated within Microsoft™ Excel by using the plotted water intake curve. A minimum R-square value of more than 0.99 was required to be considered a good fit, therefore, to obtain the best fitting regression values, the water consumption curve was divided into 3 segments. Water consumption based on the regression line in Figure 5. 4 was used if the age of the birds when they started and ended the water treatment was less or equal to 21 days of age. The regression line in Figure 5. 6 was used if the age of the birds when they started or ended the water treatment was less or equal to 38 days of age. All other age ranges had water consumption calculated from the regression line depicted in Figure 5. 5. From the regression coefficients the water consumption could then be calculated using integral calculus.

Figure 5. 4 Segment one broiler chicken daily water consumption (L/bird)

Water intake (L/day) is based the Nutreco Canada Inc. daily water consumption chart for common breeds and average performing flocks in Canada and the fitted polynomial regression lines generated in Microsoft™ Excel. Poly. = polynomial.

Figure 5. 5 Segment two broiler chicken daily water consumption (L/bird)

Water intake (L/day) is based the Nutreco Canada Inc. daily water consumption chart for common breeds and average performing flocks in Canada and the fitted polynomial regression lines generated in Microsoft™ Excel. Poly. = polynomial.

Figure 5. 6 Segment three broiler chicken daily water consumption (L/bird)

Water intake (L/day) is based the Nutreco Canada Inc. daily water consumption chart for common breeds and average performing flocks in Canada and the fitted polynomial regression lines generated in Microsoft™ Excel. Poly. = polynomial.

The area under the curve for each regression equation provided an estimate of water consumption. The equation for each segment of the curve was as follows; where the corresponding " β " values came from the regression line for each segment of the curve and the ages (t) for each treatment came from the survey (as entered).

Equation 5. 4 Formula for the three segments of the polynomial for water consumption

$$\beta_0 t + \beta_1 t^2 / 2.0 + \beta_2 t^3 / 3.0 + \beta_3 t^4 / 4.0$$

Using PLpgsql code within the PostgreSQL database, for the applicable regression line, 2 integrals were calculated, the lower integral where "t" is this the start age and the upper integral where "t" is the end age. The difference between the upper and lower integral yielded the estimate of water intake in liters per bird. Water consumption in liters/bird was then multiplied by the number of birds at risk (i.e., total birds minus half of the cumulative

mortality rate at the time of sampling) to provide an estimate of total liters consumed for each treatment. This value was then utilized to calculate the grams of antimicrobial consumed per treatment and incorporated into the quantitative analysis.

Quantity of antimicrobials used in animals:

Based on the calculations above, the milligrams of active ingredient were obtained for each route of administration, reported by route and aggregate of all routes.

Equation 5. 5 Estimation of total milligrams in feed (both pigs and broiler chickens)

$$\text{Milligrams}_{\text{Feed}} = \left(\text{animal population} - \frac{1}{2} \text{ mortality rate} \right) \times \text{feed(kg)} \times \text{level of drug} \left(\frac{\text{mg drug}}{\text{kg feed}} \right)$$

Equation 5. 6 Estimation of total milligrams in water (broiler chickens only)

$$\text{Milligrams}_{\text{Water}} = \left(\text{animal population} - \frac{1}{2} \text{ mortality rate} \right) \times \text{water(L)} \times \text{level of drug} \left(\frac{\text{mg drug}}{\text{L water}} \right)^*$$

*inclusion rate x concentration of the drug

Equation 5. 7 Estimation of total milligrams via *in ovo* or subcutaneous injections at the hatchery (broiler chickens only)

$$\text{Milligrams}_{\text{Injection}} = \left(\text{flock population} - \frac{1}{2} \text{ mortality rate} \right) \times \text{mg per hatching egg or chick}$$

Based on the quantity of feed or water consumed from the above calculations, the following antimicrobial use or metrics were reported:

- 1. Population correction unit (PCU) or biomass.** The PCU was calculated by multiplying the total number of animals included in the survey (equivalent to 1 grow-out cycle; population minus half the mortality rate) by the theoretical (standardized) weight at the most likely time of treatment (ESVAC standard weight of 1 kg for broiler and 65 kg for swine was used).

Equation 5. 8 Formula for PCU calculation

$$\text{PCU (kg)} = \text{number of animals} \times \text{average weight at treatment (kg)}$$

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

- 2. Milligrams active ingredient/Population correction unit (mg/PCU).** Total milligrams (combined injections, feed and water for broilers and feed only for pigs) for each antimicrobial/class and overall, adjusted for animal population (1 grow-out cycle) and weight.

Equation 5. 9 Formula for mg/PCU calculation

$$\text{mg/PCU} = \frac{\text{antimicrobials used in all routes of administration (mg)}}{\text{PCU (kg)}}$$

- 3. Defined Daily Doses (DDDvetCA).** The Canadian average labelled daily doses for each antimicrobial were assigned following similar methodology to ESVAC's DDDvet assignment with some exceptions⁴⁹. The average labelled dose was determined as follows: each antimicrobial was assigned a DDDvetCA by obtaining all approved doses for pigs and chickens (prevention and treatment purposes) from 2 Canadian references^{50,51} or from expert opinion, where no labeled product existed (extra-label drug use, ELDU)⁵². The sum of all the doses was then divided by the total number of unique doses. Because the labeled dose (inclusion rates) varied by pharmaceutical form (e.g., g/tonne for products administered via feed, g/L water for products administered via the drinking water, mg/chick or hatching eggs for injectable products), values were standardized in mg_{drug}/kg_{animal} based on the ESVAC approach. As in the ESVAC methodology, for combination products, DDDvetCA for each antimicrobial component was determined. The values for pigs and chickens are summarized in Table A. 3 and Table A. 4. Please note that these values may change as new products are added or become available.

Equation 5. 10 Step 1—Average daily dose calculation

$$\text{Average daily dose} = \frac{\sum (\text{all unique doses})^a}{\text{number of unique doses}}$$

⁴⁹ European Medicines Agency, 2016: Defined daily doses for animals (DDDvet) and defined course doses for animals (DCDvet). European Surveillance of Veterinary Antimicrobial Consumption (ESVAC). Accessed on January 2017.

⁵⁰ CFIA, 2016b: Compendium of Medicating Ingredient Brochure. Available at: <http://www.inspection.gc.ca/animals/feeds/medicating-ingredients/eng/1300212600464/1320602461227>. Accessed on January 2017.

⁵¹ Canadian Animal Health Institute, 2016: Compendium of Veterinary Products. Available at: <https://bam.naccvp.com/?u=country&p=msds>. Accessed on January, 2017.

⁵² Canadian Association of Poultry Veterinarians. Available at: <http://www.capv-acva.ca/BroilerChicken.htm>. Accessed on January 2017.

Equation 5. 11 Step 2—Standardization of average daily dose to obtain DDDvetCA with units in mg of drug per kilogram of body weight (animal)

$$\text{DDDvetCA} = \text{average daily dose} \times \text{conversion factor}^b$$

^aAll unique doses indicated for treatment/prevention and growth promotion were used to calculate the average daily dose of an antimicrobial; an antimicrobial may have more than one unique dose by product format and/or indication.

^bA conversion factor is used to standardize the DDDvetCA unit in mg/kg; please refer to Table A. 5 and Table A. 6 for broiler chicken and grower-finisher pig-specific conversion factors, respectively.

Equation 5. 12 Step 3—DDDvetCA with units in mg of drug per animal by the theoretical (standardized) weight at the most likely time of treatment (ESVAC standard weight of 1 kg for broiler and 65 kg for swine was used)

$$\text{DDDvetCA}_{\text{Animal}} = \text{DDDvetCA} \times \text{average weight at treatment}$$

- 4. Number of Defined Daily Doses/1,000 animal-days (nDDDvetCA/1,000 pig or chicken-days).** This step adjusted the total milligrams of antimicrobials to the above calculation (nDDDvetCA) to obtain the nDDDvetCA (each antimicrobial/class and overall). The final step adjusted the nDDDvetCA by the overall pig or chicken population included in the survey and the average days each animal was in the study (e.g., 34 days for chickens, 103 days for pigs).

Equation 5. 13 Formula for the DDDvetCa/1,000 animal-days

$$\text{Number of DDDvetCA/1,000 animal - days} = \frac{\text{grams of active ingredient/DDDvetCA}_{\text{Animal}}}{\left(\frac{\text{total animals} - \frac{1}{2} \text{ mortality rate}}{1,000} \times \text{days exposed} \right)}$$

GROWER-FINISHER PIGS

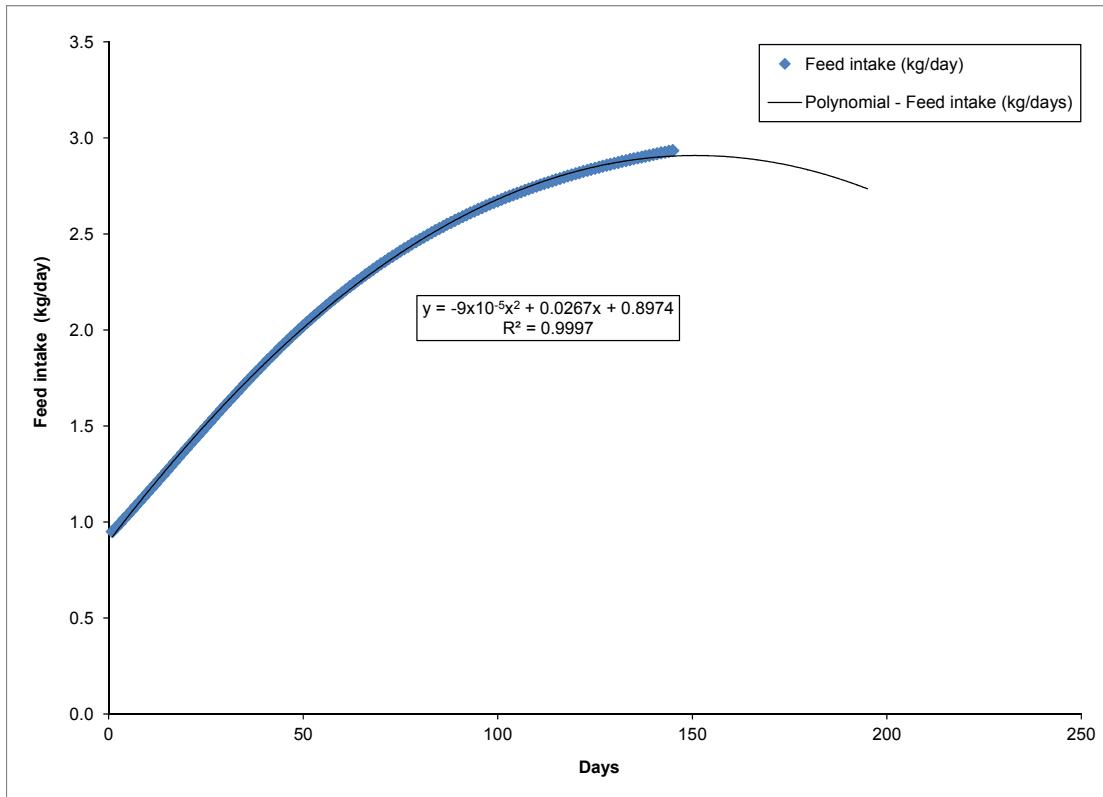
Antimicrobial exposures were summarized for each herd. An exposure was defined as any reported use of an active ingredient by a given route of administration in 2015. Data were reported as exposure to an active ingredient by a given route of administration, as well as by exposure to an active ingredient by any administration route. These exposures were summarized by antimicrobial class. It is important to note that antimicrobial exposures through feed tend to involve larger groups of pigs and longer durations of use than

antimicrobial exposures via water. Injectable antimicrobials are generally administered on an individual basis to a limited number of pigs⁵³.

Quantitative AMU data (dose and duration) were collected for antimicrobials administered through feed but not for antimicrobials administered through water or by injection. The amount of an antimicrobial consumed through feed was estimated from the concentration of the antimicrobial in a given ration multiplied by the cumulative tonnes consumed over the duration of exposure. Estimates of feed intake were based on simple regression equations and integral calculus. Plots of feed consumption per day were created within Microsoft™ Excel, using National Research Council (NRC) tables (Nutrient Requirements of Swine: Eleventh Revised Edition, National Academy of Sciences, 2012) for grower-finisher pigs. Three plots were created to reflect poor (15% less protein deposition per kg feed consumed than the standard pig), medium (standard pig described by NRC), and high (15% more protein deposition than the standard pig) performance. The lightest starting weight recorded for all rations listed on a questionnaire was selected and the corresponding day on the feed consumption table was identified. The number of days the ration was fed was then added to the start day to obtain an end day for that ration. For each successive ration, the number of days the ration was fed was added to the proceeding ration end day. When the reported feeding end day went beyond the NRC table, data were extrapolated up to maximum of 50 additional days.

Regression parameters for each level of pig performance were calculated within Microsoft™ Excel by using the feed intake curve (e.g., Figure 5. 7). A minimum R-square value higher than 0.99 was required to be considered a good fit.

⁵³ Version April, 2009. Available at: www.hc-sc.gc.ca/dhp-mps/vet/antimicrob/amr_ram_hum-med-rev-eng.php. Accessed February 2017.

Figure 5. 7 Example of daily feed (kg/day) for medium performing pigs

Feed intake (kg/day) were based on NRC feeding with fitted polynomial regression line generated in Microsoft™ Excel.

Poly. = polynomial.

The area under the curve for each regression equation provided feed intake using the following formula:

Equation 5. 14 Formula for the polynomial of feed consumption in pigs

$$\beta_0 t + \beta_1 t^2 / 2.0 + \beta_2 t^3 / 3.0$$

The corresponding β values come from the performance specific regression lines and the ages (t) came from the above described approach. Using PPlpgsql code within the PostGreSQL database for each regression line (poor, medium and high performance) 2 integrals were calculated, the lower integral where "t" is the start age and the upper integral is where "t" is the end age. The difference between the upper and lower integral yielded the estimate of feed intake in kilograms per pig for that ration. For each grower-finisher pig herd an average daily gain (ADG) was calculated. Farms were categorized as having poor, medium, or high performance by using cut off points which were generated by partitioning the survey ADG data into thirds. High performance herds were defined as herds with an ADG more than 0.8734, medium performance herds had an ADG between 0.8734 to 0.8045, and poor

performance herds had ADG less than 0.8045. Based on this categorization, the appropriate regression line and integral were applied to calculate feed consumption. Feed consumption was converted from kilograms to tonnes and multiplied by the number of pigs at risk to provide an estimate of total tonnes fed for each ration. This value was then utilized to calculate the grams of antimicrobial consumed per ration and incorporated in quantitative analyses.

ANTIMICROBIAL RESISTANCE

HUMAN SURVEILLANCE

OBJECTIVE(S)

The objective of the *Surveillance of Human Clinical Isolates* component of CIPARS is to provide a representative and methodologically unified approach to monitor temporal variations in the prevalence of antimicrobial resistance in *Salmonella* isolated from humans.

SURVEILLANCE DESIGN

Hospital-based and private clinical laboratories culture human *Salmonella* isolates in Canada. Although reporting is mandatory through laboratory notification of reportable diseases to the National Notifiable Disease Reporting System, forwarding of *Salmonella* isolates to provincial reference laboratories is voluntary and passive. A high proportion (84% in 2001)⁵⁴ of *Salmonella* isolates are forwarded to Provincial Public Health Laboratories (PPHLs), but this proportion may vary among laboratories. The Yukon, Northwest Territories, and Nunavut, which do not have a PPHL counterpart, forwarded their isolates to one of the PPHLs.

Prior to 2002, PPHLs forwarded *Salmonella* isolates to the Enteric Diseases Program, National Microbiology Laboratory (NML) @ Winnipeg, Public Health Agency of Canada (PHAC), Winnipeg, Manitoba for confirmation and subtype characterization. A letter of agreement by which provinces agreed to forward all or a subset of their *Salmonella* isolates to NML @ Winnipeg for CIPARS was signed in 2002 by the PPHLs and PHAC. This agreement officially launched the surveillance program.

To ensure a statistically valid sampling plan, all human *Salmonella* isolates (outbreak-associated and non-outbreak-associated) received passively by PPHLs in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador were forwarded to the NML. The PPHLs in more heavily populated provinces (British Columbia, Alberta, Ontario, and Québec) forwarded only the isolates received from the 1st to the 15th of each month. However, all human *S. Newport* and *S. Typhi* isolates were forwarded to the NML because of concerns of multidrug resistance and clinical importance, respectively.

The PPHLs were also asked to provide a defined set of data for each forwarded isolate, including serovar name, date collected, and patient age, sex, and province of residence.

⁵⁴ Report of the 2001 Canadian Laboratory Study, National Studies on Acute Gastrointestinal Illness, Division of Enteric, Foodborne and Waterborne Diseases, 2002.

RETAIL MEAT SURVEILLANCE

OBJECTIVE(S)

The objectives of CIPARS *Retail Meat Surveillance* component are to provide data on the prevalence of antimicrobial resistance and to monitor temporal variations in selected bacteria found in raw meat at the province/region level.

SURVEILLANCE DESIGN

Retail Meat Surveillance provides a measure of human exposure to antimicrobial-resistant bacteria via the consumption of undercooked meat. Retail food represents a logical sampling point for surveillance of antimicrobial resistance because it is the endpoint of food animal production. Through meat sample collection and testing, the retail surveillance provides a measure of human exposure to antimicrobial resistant bacteria through the consumption of meat products available for purchase by Canadian consumers. The scope of the surveillance framework can be modified as necessary (e.g., to evaluate different food commodities, bacteria, or geographic regions) and functions as a research platform for investigation of specific questions regarding antimicrobial resistance in the agri-food sector.

The unit of concern in *Retail Meat Surveillance* in 2015 was the bacterial isolate cultured from one of the commodities of interest. In this situation, the commodities were raw meat products commonly consumed by Canadians, which originated from the 3 animal species sampled in the *Abattoir Surveillance* component as well as turkey beginning in 2012. These raw meat products consisted of chicken (legs or wings [skin on]), turkey (ground), pork (chops), and beef (ground).

For ground beef, a systematic collection of extra-lean, lean, medium, and regular ground beef was performed to ensure representation of the heterogeneity of ground beef with respect to its origins (e.g., domestic vs. imported beef or raised beef cattle vs. culled dairy cattle). The meat cuts "legs or wings with skin on", "ground turkey", "pork chops", and "ground beef" were chosen on the basis of suspected high prevalences of the targeted bacterial species within and the low purchase prices of these commodities⁵⁵ and for comparability to other international retail surveillance programs .

Bacteria of interest in chicken and turkey were *Campylobacter*, *Salmonella*, and generic *E. coli*. In pork, both *Salmonella* and *E. coli* were cultured, but only isolates of *E. coli* underwent antimicrobial susceptibility testing for routine surveillance. *Salmonella* was isolated from pork mainly to provide recovery estimates from this commodity for other Public Health Agency of Canada programs. Because the prevalence of *Salmonella* in pork is low, antimicrobial susceptibility results are not presented on an annual basis but are pooled and presented over a multi-year period in the interest of precision. Recovery of *Campylobacter* from pork was not attempted because of the low prevalence observed in the initial stages of *Retail Meat Surveillance*. In beef, only *E. coli* was cultured and then tested for antimicrobial susceptibility

⁵⁵ Ravel A. Antimicrobial Surveillance in food at retail – Proposal for a pilot project. 2002. 13 pp.

given the low prevalence of *Campylobacter* and *Salmonella* in this commodity at the retail level, as determined during the early phase of the program.

SAMPLING METHODS

Generally, the sampling protocol was designed to evaluate antimicrobial resistance in certain bacterial species that contaminate retail meat and to which Canadian consumers may subsequently be exposed. In 2015, it primarily involved continuous weekly submission of samples of retail meat from randomly selected geographic areas (i.e., census divisions defined by Statistics Canada), weighted by population, in each participating province.

In 2015, retail meat samples were collected in British Columbia, Prairies (a region including the provinces of Saskatchewan, Alberta, and Manitoba⁵⁶), Ontario, and Québec. Unlike recent years (2013 and 2014), no data were presented in 2015 for the Atlantic region (a region including the provinces of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador⁵⁷) as retail sampling activities in this region were suspended due to budgetary constraints. Additionally, during the 2015 sampling year in Ontario, only a partial year's worth of retail sampling was conducted due to the availability of sampling technician staff. As a result, the sampling target and subsequent isolate yields in this province were not achieved and therefore, all retail data presented for Ontario in 2015 should be interpreted with caution.

Data from Statistics Canada were used to define strata. This was done by using cumulative population quartiles (or tertiles from a list of census divisions in a province, sorted by population in ascending order. Generally, between 15 and 18 census divisions per province/region were then chosen by means of stratified random selection and weighted by population within each stratum. The number of sampling days allocated to each stratum was also weighted by population and is summarized as follows:

BRITISH COLUMBIA

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

⁵⁶ No retail sampling was conducted in Manitoba to-date.

⁵⁷ No retail sampling was conducted in Newfoundland and Labrador.

PRAIRIES

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

ONTARIO and QUÉBEC

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

Generally, field workers in Ontario⁵⁸ and Québec conducted sampling on a weekly basis, and those in British Columbia and the Prairie region conducted sampling every other week. Sampling was less frequent in British Columbia and the Prairie region because of funding constraints, limited laboratory capacity, and a desire to avoid over-sampling at particular stores. Samples were collected on Mondays or Tuesdays for submission to the laboratory by Wednesday. Samples submitted from outside Québec were sent to the same laboratory via 24-hour courier.

In each province, 2 census divisions were sampled each sampling week. In each census division, 4 stores were selected prior to the sampling day, based on store type. Generally, 3 chain stores and 1 independent market or butcher shop were selected. An exception to this protocol was made in densely populated urban census divisions (e.g., Toronto or Montréal), where 2 chain stores and 2 independent markets or butcher shops were sampled to reflect the presumed shopping behaviour of that subpopulation. Generally speaking, from each store type, 1 sample of each commodity of interest was attempted, for a desired total of 15 meat samples (4 chicken, 4 turkey, 4 pork, and 3 beef samples) per division per sampling day⁵⁹. When possible, specific stores were sampled only once per sampling year. In some cases due to reduced availability of certain meats and store closures etc., the desired sample yield was not achieved.

Prevalence estimates were used to determine the numbers of samples to be collected, which were based on an expected yield of 100 isolates per commodity per province per year, plus 20% to account for lost or damaged samples. Because sampling was less frequent in British

⁵⁸ For 2015, due to limited sampling technician availability, only a partial year's worth of retail sampling was conducted in Ontario. Sampling target and isolate yields were therefore not achieved in Ontario. All 2015 Ontario retail data should be interpreted with caution.

⁵⁹ At 1 store in each division (except the Atlantic region), the beef sample was not collected to minimize over-sampling of this commodity.

Columbia and the Prairie region than in Ontario⁶⁰ and Québec, the target of 100 isolates per year may not have always been met in those provinces/regions.

Personal digital assistants (PDAs) were used to capture the following store and sample data:

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

Individual samples were packaged in sealed zipper-type bags and placed in 16 L thermal coolers for transport. The ambient environmental temperature was used to determine the number of ice packs placed in each cooler (i.e., 1 ice pack for temperatures below 20°C and 2 ice packs for temperatures 20°C or higher). In 1 or 2 coolers per sampling day, instruments for recording temperature data⁶¹ were used to monitor temperatures to which samples were exposed.

ABATTOIR SURVEILLANCE

OBJECTIVE(S)

The objectives of the CIPARS *Abattoir Surveillance* component are to provide nationally representative, annual antimicrobial resistance data for bacteria isolated from animals entering the food chain, and to monitor temporal variations in the prevalence of antimicrobial resistance in these bacteria.

SURVEILLANCE DESIGN

Abattoir Surveillance only includes animals that originated from premises within Canada. Established in September 2002, this component initially targeted generic *Escherichia coli* and *Salmonella* within the food animal commodities associated with the highest per capita meat consumption: beef cattle, broiler chickens, and pigs. In 2003, the component was refined to discontinue *Salmonella* isolation from beef cattle because of the low prevalence of *Salmonella* in that population. *Campylobacter* surveillance was initiated in beef cattle in late 2005 in

⁶⁰ For 2015, due to limited sampling technician availability, only a partial year's worth of retail sampling was conducted in Ontario. Sampling target and isolate yields were therefore not achieved in Ontario. All 2015 Ontario retail data should be interpreted with caution.

⁶¹ Ertco Data Logger™, West Patterson, NJ, USA.

order to include a pathogen in beef cattle surveillance and to provide data on fluoroquinolone resistance, following the approval of a fluoroquinolone for use in cattle. *Campylobacter* surveillance was also initiated in chickens in 2010 and pigs in 2012.

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

Over 90% of all food-producing animals in Canada are slaughtered in federally inspected abattoirs annually⁶². The program is based on the voluntary participation of federally inspected slaughter plants from across Canada. The sampling method was designed with the goal that, across Canada, 150 isolates of *Salmonella* and generic *E. coli* and 100 isolates of *Campylobacter* would be recovered from each of the 3 animal species over a 12 month period. These numbers represented a balance between acceptable statistical precision and affordability⁶³. The actual number of samples collected was determined for each food animal species on the basis of the expected caecal prevalence of the bacteria in that animal species. For example, if the goal was 150 isolates and the expected bacterial prevalence was 10%, then 1,500 samples would need to be collected and submitted for bacterial isolation.

The sampling design was based on a 2-stage sampling plan, with each commodity handled separately. The first stage consisted of random selection of federally inspected slaughterhouses. The probability of an abattoir being selected was proportional to its annual slaughter volume. The second stage involved systematic selection of animals on the slaughter line. The annual number of caecal samples collected at each abattoir was proportional to its slaughter volume.

SAMPLING METHODS

To minimize shipping costs and allow each abattoir to maintain efficiency, the annual total number of samples to be collected in each abattoir was divided by 5, resulting in the number of collection periods. For each collection period, 5 to 7 caecal samples were collected within 5 days, at the convenience of the slaughterhouse staff, provided the 5 animals and associated samples originated from different groups. Sampling from different groups of animals was important to maximize diversity and avoid bias attributable to overrepresentation of particular producers. Collection periods were uniformly distributed throughout the year to avoid any bias that may have resulted from seasonal variation in bacterial prevalence and antimicrobial susceptibility test results.

⁶² Agriculture and Agri-Food Canada. Red meat market information. Available at: www.agr.gc.ca/redmeat-vianderouge/index_eng.htm. Accessed September 2014.

⁶³ Ravel A. Development of the Canadian antimicrobial resistance surveillance system (agri-food sector)—sampling design options. Presented to the National Steering Committee on Antimicrobial Resistance in Enterics, Canada, 2001. 79 pp.

Thirty-nine federally inspected slaughter plants (6 beef cattle plants, 27 poultry plants, and 14 swine plants) from across Canada participated in the 2015 CIPARS *Abattoir Surveillance* component. These plants represented over 70% of the animals slaughtered at federally inspected abattoirs in Canada in 2015. Samples were obtained according to a predetermined protocol, with modifications to accommodate various production-line configurations in the different plants. Protocols were designed to avoid conflict with carcass inspection methods, plant-specific Food Safety Enhancement Programs, and Health and Safety requirements. They were also designed to avoid situations of potential cross-contamination. All samples were collected by industry personnel under the oversight of the Veterinarian-in-Charge of the Canadian Food Inspection Agency.

FARM SURVEILLANCE

OBJECTIVE(S)

The objectives of the CIPARS *Farm Surveillance* component are to provide data on antimicrobial use and resistance, to monitor temporal trends in the prevalence of antimicrobial resistance, to investigate associations between antimicrobial use and resistance on grower-finisher pigs, and broiler chickens, and to provide data for human health risk assessments.

SURVEILLANCE DESIGN

The *Farm Surveillance* component was the third active surveillance component implemented by CIPARS. Taken together, with the *Abattoir Surveillance* and *Retail Meat Surveillance* components, these data validate the information collected at key points along the farm-to-fork food production chain. This initiative is built on a sentinel farm framework.

Questionnaires are used to collect data on farm demographics, animal health and antimicrobial use. Composite pen fecal samples are collected and submitted to laboratories for bacterial isolation and antimicrobial susceptibility testing. The bacteria of interest in broiler chickens were *Campylobacter*, *Salmonella*, and generic *E. coli* and were *Salmonella* and *E. coli* in grower-finisher pigs.

BROILER CHICKENS

The CIPARS *Farm Surveillance* broiler chicken component was initiated in April 2013 in the 4 major poultry-producing provinces in Canada (British Columbia, Alberta, Ontario, and Québec). In 2014, due to external funding from Saskatchewan Agriculture, Saskatchewan also started to participate in the program. The Broiler *Farm Surveillance* component samples flocks at least 1 week before shipment for slaughter (i.e., pre-harvest stage). This stage of production was selected because it is most proximal to the consumer of all the farm production stages. Half of the flocks sampled for the year were also sampled at the time of chick placement to determine the resistance profiles of chicks on arrival and carry-over of resistant organism from the previous flock.

GROWER-FINISHER PIGS

CIPARS *Farm Surveillance* swine component was initiated in 2006 in the 5 major pork-producing provinces in Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Québec). The swine industry was selected as the pilot commodity for development of the *Farm Surveillance* infrastructure because the Canadian Quality Assurance (CQA®) program had been extensively implemented by the industry and because, in 2006, unlike in the other major livestock commodities, there had not been a recent outbreak of foreign animal disease in pigs. The *Farm Surveillance* component concentrates on grower-finisher pigs. Pigs in this stage of production were chosen because of their proximity to the consumer.

SAMPLING METHODS

BROILER CHICKENS

Poultry veterinarians recruited sentinel flocks to participate in this voluntary national surveillance program. The number of sentinel flocks allocated to each of the 4 participating province/regions (British Columbia, Prairies [Alberta and Saskatchewan], Ontario and Québec) was proportional to the national total of quota-holding producers, except in the FoodNet Canada sentinel sites, where a minimum of 30 flocks were sampled. In Alberta, laboratory testing for all flocks was provided by the Alberta Agriculture and Forestry, Agri-Food Laboratories Branch. In Saskatchewan, the Saskatchewan Ministry of Agriculture provided full financial support for 9 flocks.

To preserve the anonymity of participating producers, poultry veterinarians collected the samples and data and submitted coded information to Public Health Agency of Canada (PHAC). The Canadian Hatchery Federation (CHF) and the Canadian Poultry and Egg Processors Council ensured confidentiality by holding the key to hatcheries; only the coded information was known to PHAC.

Poultry veterinary practices were purposively selected from each province. Each veterinarian recruited a predetermined number of sentinel farm sites proportional to their practice profile and availability by use of specific inclusion and exclusion criteria. To be included, farms were required to be a Safe, Safer, Safest™ compliant quota-holding broiler operations (i.e., broilers are the major commodity reared on-site but producers may also have other animal species and/or commodities). Antibiotic-free, raised without antibiotics or organic production systems were selected proportional to the veterinarian's practice profile. Veterinarians also ensured that selected farms were also representative of all the CHF hatcheries supplying chicks and representative of the feed mills supplying feeds in the province of their practice, and were geographically distributed (i.e., not neighboring flocks). Additionally, these farms were demographically reflective of the veterinary practice and overall broiler industry profile (e.g., variety of flock management: poor to excellent performing flocks, variety in volume of chicks placed: low to high flock densities). These criteria helped ensure that the flocks enrolled were representative of most broiler flocks raised in Canada. The veterinarians were also asked to distribute their sampling visits across the year to account for seasonal variations in pathogen prevalence and diseases that may drive AMU at the hatchery and on farms.

Sentinel broiler flocks were visited during the last week of growth (chickens more than 30 days of age), once per year for sample and data collection. Four pooled fecal samples, representing one per floor quadrant with at least 10 fecal droppings were collected from randomly selected barns and floors (if multiple level/pen barn). On a trial basis, a proportion of the flocks were also visited when the chicks arrived at the barn. Using a sterile sponge, 2 environmental barn surface samples and 3 meconium samples were collected. The meconium samples were collected from the liners (chick pads) of the boxes used to ship chicks from the hatchery to the barn.

GROWER-FINISHER PIGS

Swine veterinarians recruited sentinel herds to participate in this voluntary national surveillance program. The number of sentinel herds allocated to each of the 5 participating provinces was proportional to the national total of grower-finisher pig units, except in Saskatchewan, where 3 additional sentinel herds were included. Support for the 3 extra herds, was provided by the Saskatchewan Ministry of Agriculture.

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

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

Sentinel grower-finisher pig herds were visited once per year for sample and data collection. Pooled fecal samples were collected from 6 pens of pigs that were close to market weight (i.e., more than 80 kg [175 lb]). Veterinarians were asked to distribute their sampling visits across the year to account for seasonal variations in pathogen prevalence and diseases that may drive AMU on farms.

SURVEILLANCE OF ANIMAL CLINICAL ISOLATES

OBJECTIVE(S)

The objective of *Surveillance of Animal Clinical Isolates* is to detect emerging antimicrobial resistance patterns as well as new serovar/resistance pattern combinations in *Salmonella*.

SURVEILLANCE DESIGN

This component of CIPARS relies on samples that are typically collected and submitted to veterinary diagnostic laboratories by veterinarians and/or producers. Consequently, sample collection and submission, as well as *Salmonella* isolation techniques varied among laboratories over the year.

Salmonella isolates were sent by provincial and private animal health laboratories from across the country to the *Salmonella* Typing Laboratory (STL) at the National Microbiology Laboratory (NML) @ Guelph with the exception of Québec, where isolates from animal health laboratories were sent to the Laboratoire d'épidémiologie et de surveillance animale du Québec, du ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec for serotyping. Isolates and serotyping results for *S. Enteritidis* and *S. Typhimurium* from Québec were then forwarded to the NML @ Guelph for phage typing and antimicrobial resistance testing. Isolates from Québec that were not *S. Enteritidis* or *S. Typhimurium* were serotyped at NML @ Guelph. It is important to note that not all isolates received by provincial animal health laboratories were forwarded to the NML @ Guelph, with the exception of isolates received by laboratories in British Columbia, Ontario, Québec, and Prince Edward Island. Therefore, coverage may have varied considerably among provinces.

Samples submitted for testing may have been collected from sick animals, animal feed, the animal's environment, or non-diseased animals from the same herd or flock. Results from chicken, turkey, cattle, pigs, and horses are reported. Cattle isolates could have originated from dairy cattle, milk-fed or grain-fed veal, or beef cattle. Chicken isolates were largely from layer hens or broiler chickens, but could also have been from primary layer breeders or broiler breeder birds. A proportion of the turkey isolates might have been recovered from turkey-related environmental samples.

FEED AND FEED INGREDIENTS

SAMPLING DESIGN

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

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

BACTERIAL ISOLATION METHODS

All samples were cultured by use of standard protocols as described below. All primary isolation of human *Salmonella* isolates was conducted by hospital-based or private clinical laboratories in participating provinces/regions. Most primary isolation of *Escherichia coli*, *Salmonella*, and *Campylobacter* from agri-food samples was conducted at the National Microbiology Laboratory (NML) @ Saint-Hyacinthe. Part of the primary isolation for *Farm Surveillance* was conducted at the Agri-Food Laboratory of the Alberta Agriculture and Rural Development. Samples from the CIPARS *Surveillance of Animal Clinical Isolates* component were cultured by various participating laboratories. Most primary bacterial isolation of samples from Feed and Feed Ingredients was conducted by the CFIA—Laboratory Services Division (Calgary or Ottawa).

SALMONELLA

SURVEILLANCE OF HUMAN CLINICAL ISOLATES

Hospital-based and private clinical laboratories isolated and identified *Salmonella* from human samples according to approved methods^{64,65,66,67}.

SURVEILLANCE OF AGRI-FOOD ISOLATES (Retail Meat Surveillance, Abattoir Surveillance, and Farm Surveillance)

The method used to isolate *Salmonella* was a modification of the MFLP-75 method⁶⁸. This method allowed isolation of viable and motile *Salmonella* from fecal (*Farm Surveillance*)

⁶⁴ Kauffman F. The Bacteriology of Enterobacteriaceae. Baltimore: Williams and Wilkins Co, 1966.

⁶⁵ Ewing WH. Edwards and Ewing's Identification of Enterobacteriaceae. 4th ed. New York: Elsevier Science Publishing Co, 1986.

⁶⁶ Le Minor L. Guidelines for the preparation of *Salmonella* antisera. Paris, France: WHO Collaborating Centre for Reference and Research on Salmonella, Pasteur Institute, 2001.

⁶⁷ Murray PR, Baron EJ, Pfaffer MA, et al, eds. Manual of Clinical Microbiology. 8th ed. Washington DC, ASM Press, 2005.

matter, caecal (*Abattoir Surveillance*) content, and meat (*Retail Meat Surveillance*) from agri-food samples. It is based on the ability of *Salmonella* to multiply and be motile in modified semi-solid Rappaport Vassiliadis (MSRV) medium at 42°C.

Retail Meat Surveillance: depending on the sample type either 1 chicken leg⁶⁹, 1 pork chop or 25 g of ground turkey was added to 225 mL of Buffered Peptone Water (BPW). One hundred milliliters of the peptone rinse were kept for *Campylobacter* and/or *E. coli* isolation. Chicken and turkey samples were left in the remaining volume of peptone rinse and incubated at 35 ± 1°C for 24 hours. Afterward, a MSRV plate was inoculated with 0.1 mL of the rinse and incubated at 42 ± 1°C for 24 to 72 hours. Migration ≥ 20mm were then streaked onto MacConkey agar. Suspect colonies were screened for purity and used to inoculate triple-sugar-iron and urea agar slants. Presumptive *Salmonella* isolates were assessed using the indole test, and their identities were verified by means of slide agglutination with *Salmonella* Poly A-I and Vi antiserum.

Abattoir Surveillance and Farm Surveillance: a 25 g portion of each pig caecal or fecal sample and broiler chicken caecal or fecal samples were mixed with 225 mL of BPW. Chicken caecal/fecal contents were weighed and mixed with BPW at a ratio of 1:10. Environmental and chick meconium sponges were mixed with 100 mL of BPW. Samples were incubated at 35 ± 1°C for 24 hours. Afterward, the method used was the same as the one described in the *Salmonella—Retail Meat Surveillance* section.

SURVEILLANCE OF ANIMAL CLINICAL ISOLATES

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

FEED AND FEED INGREDIENTS

Under both Canadian Food Inspection Agency programs (15A and 15E), all samples were collected aseptically and submitted for bacterial culture and isolation. For *Salmonella* isolation, MSRV medium was used.

ESCHERICHIA COLI

RETAIL MEAT SURVEILLANCE

Fifty milliliters of the peptone rinse prepared as stated in the *Salmonella—Retail Meat Surveillance* section were mixed with 50 mL of double strength EC Broth and incubated at 42 ± 1°C for 24 hours. One loopful of the mixture was then streaked onto Eosin Methylene Blue agar and incubated at 35 ± 1°C for 24 hours. Suspect colonies were screened for purity and

⁶⁸ Compendium of Analytical Methods, Health Protection Branch, Methods of Microbiological Analysis of Food, Government of Canada.

⁶⁹ When legs with skin on were not available, wings with skin on or other cuts were purchased instead.

transferred onto trypticase soy agar with 5% sheep blood. Presumptive *E. coli* colonies were assessed using Simmons citrate and indole tests. The *E. coli* isolates with negative indole test results were confirmed using a bacterial identification test kit⁷⁰.

ABATTOIR SURVEILLANCE AND FARM SURVEILLANCE

One drop of the peptone mixture prepared as earlier stated in the Surveillance of Agri-Food Isolates/*Salmonella*—Abattoir Surveillance and Farm Surveillance section was streaked onto MacConkey agar and incubated at $35 \pm 1^\circ\text{C}$ for 18 to 24 hours. Suspect lactose-fermenting colonies were screened for purity and transferred onto Luria-Bertani agar. Presumptive *E. coli* colonies were assessed as in the Retail Meat Surveillance for *E. coli*.

CAMPYLOBACTER

RETAIL MEAT SURVEILLANCE

Fifty milliliters of the peptone rinse prepared as previously stated in the *Salmonella*—Retail Meat Surveillance section, were mixed with 50 mL of double-strength Bolton broth and incubated in a microaerophilic atmosphere at $42 \pm 1^\circ\text{C}$ for 44 to 48 hours. A swab saturated with broth was then swabbed then streaked using 3 quadrants onto a modified Charcoal Cefoperazone Deoxycholate Agar (mCCDA) plate and incubated in a microaerophilic atmosphere at $42 \pm 1^\circ\text{C}$ for 24 to 72 hours. Suspect colonies were streaked onto a second mCCDA and incubated. From the second mCCDA plate, a colony was then streaked onto a Mueller Hinton with citrated sheep's blood agar plate and incubated in a microaerophilic atmosphere at $42 \pm 1^\circ\text{C}$ for 24 to 48 hours. Presumptive *Campylobacter* colonies were identified using the following tests: Gram stain, oxidase, and catalase. A multiplex PCR (mPCR)⁷¹ was used to speciate colonies. Specific genomic targets (hippuricase in *C. jejuni* and aspartokinase in *C. coli*) were amplified by mPCR from bacterial lysates. Products were visualized on agarose gel and identified based on their specific molecular size using the QIAxcel® method⁷². An internal universal control (16s rRNA) was incorporated into the PCR method. The priming oligonucleotides used in the PCR were highly specific for *C. jejuni* or *C. coli* and will not amplify DNA present in any other *Campylobacter* spp. or non-*Campylobacter* organisms. Unidentified species of *Campylobacter* are collectively referred to in the CIPARS reports as "*Campylobacter* spp.". However, when used alone, the term "*Campylobacter*" refers to all *Campylobacter* species.

⁷⁰ API® 2OE system.

⁷¹ The multiplex PCR speciation of *Campylobacter jejuni* and *Campylobacter coli* was based on the following published method. Person S, KE Olsen. Multiplex PCR for identification of *Campylobacter coli* and *Campylobacter jejuni* from pure cultures and directly on stool samples. J Med Microbiol 2005; 54:1043–1047.

⁷² Qiagen®. QIAxcel® DNA Handbook, 5th Edition November 2014. Available at: <https://www.qiagen.com/ca/resources/resourcedetail?id=f6158498-a857-4a2f-b40b-569fba3793e2&lang=en>. Accessed on October 2016.

ABATTOIR SURVEILLANCE AND FARM SURVEILLANCE

One milliliter of BPW mixture prepared as previously stated in the *Salmonella—Abattoir Surveillance* and *Farm Surveillance* sections, was mixed with 9 mL of Hunt's enrichment broth (HEB) and incubated in a microaerophilic atmosphere at $35 \pm 1^\circ\text{C}$ for 4 hours. After this first incubation, 36 µL of sterile cefoperazone were added to the HEB tubes which were then sent back to microaerophilic incubation, this time at $42 \pm 1^\circ\text{C}$ for 20 to 24 hours. A swab saturated with HEB was then used to inoculate a mCCDA plate and incubated at $42 \pm 1^\circ\text{C}$ in microaerophilic conditions for 24 to 72 hours. Suspect colonies were assessed as described earlier in the *Campylobacter—Retail Meat Surveillance* section.

SEROTYPING AND PHAGE TYPING METHODS

SALMONELLA

SURVEILLANCE OF HUMAN CLINICAL ISOLATES

In general, clinical laboratories forwarded their *Salmonella* isolates to their Provincial Public Health Laboratory (PPHL) for identification and serotyping. The PPHL further forwarded *Salmonella* isolates to the National Microbiology Laboratory (NML) @ Winnipeg according to the predefined testing protocol. Isolate identities were confirmed by the NML @ Winnipeg when isolates received did not have a serovar name⁷³ or when inconclusive results arose during phage typing. The O or somatic antigens of the *Salmonella* isolates were serotyped by use of a slide agglutination method⁷⁴. At the NML @ Winnipeg, *Salmonella* H or flagellar antigens were detected via slide and confirmatory tube agglutination methods. *Salmonella* isolates were maintained at room temperature between 25° and 35°C until typed.

Phage typing was performed at the NML @ Winnipeg for isolates of the following *Salmonella* serovars: Enteritidis, Heidelberg, Typhimurium, Hadar, Newport, Typhi, Paratyphi B⁷⁵, Paratyphi B var. L(+) tartrate (+), Infantis, Thompson, Oranienburg, Panama, 4,[5],12:b:-, and 4,[5],12:i:-. For phage typing the standard technique described by Anderson and Williams⁷⁶ was followed. Isolates were streaked onto nutrient agar plates and incubated at 37°C for 18 hours. Three to 5 smooth colonies were selected and used to inoculate 4.5 mL of phage broth⁷⁷, which was then incubated for 1.5 to 2 hours in a shaking water bath at 37°C to attain bacterial growth with a turbidity equivalent to 1 McFarland standard. Phage agar plates⁷⁸ were flooded with approximately 2 mL of culture medium, and the excess liquid was removed with a Pasteur pipette. Flooded plates were allowed to dry for 15 minutes at room temperature. Afterward, approximately 10 µL of each serovar-specific typing phage was used to inoculate the bacterial lawn by means of a multiple inoculating syringe method⁷⁹. The plates were incubated at 37°C overnight, and lytic patterns were subsequently interpreted⁸⁰.

Salmonella Enteritidis strains were phage typed with typing phages obtained from the International Centre for Enteric Phage Typing (ICEPT), Central Public Health Laboratory,

⁷³ Grimont PAD, Weill F-X. Antigenic formulae of the *Salmonella* serovars. 9th ed. Paris, France: WHO Collaborating Centre for Reference and Research on *Salmonella*, Institut Pasteur, 2007.

⁷⁴ Ewing WH. Edwards and Ewing's Identification of Enterobacteriaceae. 4th ed. New York: Elsevier Science Publishing Co, 1986.

⁷⁵ *Salmonella* Paratyphi B does not include *S. Paratyphi* B var. L (+) tartrate (+), formerly called *S. Paratyphi* var. Java. The biotype of *S. Paratyphi* B included here is tartrate (-) and associated with severe typhoid-like fever. *Salmonella* Paratyphi B var. L (+) tartrate (+) is commonly associated with gastrointestinal illness.

⁷⁶ Anderson E, Williams R. Bacteriophage typing of enteric pathogens and staphylococci and its use in epidemiology. J Clin Pathol 1956; 9: 94–127.

⁷⁷ Difco™ phage broth, Difco Laboratories, Baltimore, MD; pH 6.8.

⁷⁸ Difco™ phage agar, Difco Laboratories.

⁷⁹ Farmer J, Hickman F, Sikes J. Automation of *Salmonella* typhi phage-typing. Lancet 1975; 2(7939): 787–790.

⁸⁰ Anderson E, Williams R. Bacteriophage typing of enteric pathogens and staphylococci and its use in epidemiology. J Clin Pathol 1956; 9: 94–127.

Colindale, United of Kingdom⁸¹. The phage-typing protocol and phages for *S. Typhimurium*, developed by Callow⁸² and further extended by Anderson⁸³ and Anderson and colleagues⁸⁴ were obtained from the ICEPT. The *S. Heidelberg* phage typing protocol and phages were supplied by the NML @ Winnipeg⁸⁵. Isolates that reacted with the phages but did not conform to any recognized phage type were designated as atypical. Strains that did not react with any of the typing phages were designated as "untypable".

The Identification and Serotyping and the Phage Typing units at the NML @ Winnipeg have attained International Standards Organization (ISO) 17025 accreditation by the Standards Council of Canada. These identification and Serotyping, Phage Typing, and Antimicrobial Resistance units participate in the annual Global Food-borne Infections Network (WHO-GFN), External Quality Assurance System of the World Health Organization, the Enter-net (a European network for the surveillance of human gastrointestinal infections) proficiency program for *Salmonella*, and a strain exchange with the NML @ Guelph and NML @ Saint-Hyacinthe (*Salmonella* and *Escherichia coli*). The NML @ Winnipeg and the Centre for Foodborne, Environmental and Zoonotic Infectious Diseases have been strategic planning members of the WHO-GFN program since 2002.

SURVEILLANCE OF AGRI-FOOD, ANIMAL CLINICAL AND FEED ISOLATES

Animal clinical *Salmonella* isolates from Québec were serotyped at the Laboratoire d'épidémiologie et de surveillance animale du Québec, du ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec and were sent to the *Salmonella* Typing Laboratory (STL) @ Guelph⁸⁶. Isolates of *S. Enteritidis* and *S. Typhimurium* were not re-serotyped, they were only phage typed. All other *Salmonella* isolates sent to STL by MAPAQ were serotyped; *S. Heidelberg* isolates were also phage typed. All other *Salmonella* isolates tested as part of CIPARS, including clinical isolates from other provinces, were submitted to the STL for serotyping and phage typing. The serotyping method detects O or somatic antigens of the *Salmonella* isolates via slide agglutination⁸⁷. The H or flagellar antigens were identified with a microtitre plate well precipitation method⁸⁸. The antigenic formulae of the *Salmonella* serovars as reported by Grimont and Weill⁸⁹ were used to identify and name the serovars.

⁸¹ Ward L, de Sa J, Rowe B. A phage-typing scheme for *Salmonella* Enteritidis. Epidemiol Infect 1987; 99: 291–294.

⁸² Callow B. A new phage typing scheme for *Salmonella* Typhimurium. J Hyg (Lond) 1959; 57: 346–359.

⁸³ Anderson E. The phagotyping of *Salmonella* other than *S. Typhi*. In: Van Oye E, ed. The World Problem of Salmonellosis. The Hague, The Netherlands: Dr W. Junk Publishers, 1964; 89–100.

⁸⁴ Anderson E, Ward L, de Saxe M, et al. Bacteriophage-typing designations of *Salmonella* Typhimurium. J Hyg (Lond) 1977; 78: 297–300.

⁸⁵ Demczuk W, Soule G, Clark C, et al. Phage-based typing scheme for *Salmonella* enterica serovar Heidelberg, a causative agent of food poisonings in Canada. J Clin Microbiol 2003; 41: 4279–4284.

⁸⁶ Office Internationale des Épidémies (OIE); All World Organisation for Animal Health, Reference Laboratory for Salmonellosis, Guelph, Ontario.

⁸⁷ Ewing WH. Edwards and Ewing's Identification of Enterobacteriaceae. 4th ed. New York: Elsevier Science Publishing Co, 1986.

⁸⁸ Shipp C, Rowe B. A mechanised microtechnique for *Salmonella* serotyping. J Clin Pathol 1980; 33: 595–597.

⁸⁹ Grimont PAD, Weill F-X. Antigenic Formulae of the *Salmonella* Serovars. 9th ed. Cedex, France: Collaborating Center for Reference and Research on *Salmonella*, Institut Pasteur, 2007.

For phage typing, the standard technique by Anderson and Williams⁹⁰ and described above was followed. Phage typing was performed on isolates of *S. Enteritidis*, *S. Typhimurium*, and *S. Heidelberg*; the sources of the typing phages for these 3 serovars were the same as described above for *Surveillance of Human Clinical Isolates*.

The STL is ISO 17025 accredited by the Standards Council of Canada. The STL participates in the annual inter-laboratory exchange of serotyping panels with up to 3 other laboratories and External Quality Assurance System of the World Health Organization proficiency program. Every year, the STL participates successfully in phage typing proficiency panels from the NML @ Winnipeg.

ANTIMICROBIAL SUSCEPTIBILITY TESTING METHODS

All *Salmonella* isolates of human origin were tested for antimicrobial susceptibility at the National Microbiology Laboratory (NML) @ Winnipeg and all *Salmonella* isolates of agri-food or feed origin were tested for antimicrobial susceptibility at the NML @ Guelph. The majority of *Campylobacter* and *Escherichia coli* isolates from all agri-food components were tested at the NML @ Saint-Hyacinthe. One isolate per positive sample was submitted for antimicrobial susceptibility testing.

The NML @ Winnipeg is a World Health Organization Collaboration Centre for Preparedness and Response to Enteric Pathogens and their Antimicrobial Resistance. The NML @ Guelph and NML @ Saint-Hyacinthe laboratories, and Atlantic Veterinary College participate in external proficiency programs for antimicrobial susceptibility testing for *Salmonella* and *E. coli*. The NML @ Guelph and NML @ Saint-Hyacinthe laboratories participate in inter-agency proficiency programs for identification and antimicrobial susceptibility testing of *Salmonella*, *E. coli*, and *Campylobacter* with the National Antimicrobial Resistance Monitoring System, United States (NARMS). The NML @ Guelph laboratory and NML @ Saint-Hyacinthe are ISO/IEC 17025-accredited for antimicrobial sensitivity testing.

SALMONELLA AND ESCHERICHIA COLI

The minimum inhibitory concentration (MIC) values for *Salmonella* and *E. coli* were determined by use of an automated broth microdilution method^{91,92}. This automated incubation and reading system uses microtitre plates containing various concentrations of dehydrated antimicrobials. The CMV3AGNF plate⁹³ was designed by the NARMS and contains 14 antimicrobials (see Table 5. 2, Antimicrobial Susceptibility Breakpoints’ section).

Isolates were streaked onto a Mueller Hinton plate and incubated at $35 \pm 1^\circ\text{C}$ for 18 to 20 hours to obtain isolated colonies. One colony was chosen from the plate and re-streaked onto Mueller Hinton agar plates for growth. The plates were incubated at $35 \pm 1^\circ\text{C}$ for 18 to 20 hours. A 0.5-

⁹⁰ Anderson E, Williams R. Bacteriophage typing of enteric pathogens and staphylococci and its use in epidemiology. *J Clin Pathol* 1956; 9: 94–127.

⁹¹ Clinical and Laboratory Standards Institute (CLSI) M7-A10.

⁹² Sensititre™, Automated Microbiology System, Trek™ Diagnostic Systems Ltd, West Sussex, England.

⁹³ Sensititre™, Trek™ Diagnostic Systems Ltd, West Sussex, England.

McFarland suspension was prepared by transferring bacterial growth from the agar plates into 5.0 mL of sterile, demineralized water. Ten microliters of the water-bacteria suspension were transferred to 11 mL of Mueller Hinton broth (MHB). This suspension was dispensed onto CMV3AGNF testing plates at 50 µL per well and the plates were sealed with adhesive plastic sheets. After an 18-hour incubation at 35 ± 1°C the plates were read automatically with the fluorometric plate reading system⁹⁴. In accordance with standards set by the Clinical and Laboratory Standards Institute (CLSI)⁹⁵, *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 of the MIC values.

CAMPYLOBACTER

The MIC values for *Campylobacter* were determined by means of the broth microdilution method⁹⁶. The CAMPY plates⁹³ designed by NARMS and containing 9 dehydrated antimicrobials were used (see Table 5. 3, Antimicrobial Susceptibility Breakpoints' section). Colonies were streaked onto Mueller Hinton agar plates with 5% sheep blood and incubated in a microaerophilic atmosphere at 42 ± 1°C for 24 hours. A 0.5-McFarland suspension of bacterial growth was prepared by transferring selected bacterial colonies into a tube containing 5 mL of MHB. Afterward, 100 µL of the MHB were transferred to 11 mL of MHB with laked horse blood. The mixture was dispensed onto CAMPY plates at 100 µL per well. The plates were sealed with perforated adhesive plastic sheets. After a 24-hour incubation in microaerophilic atmosphere at 42 ± 1°C, plates were read using the Sensititre Vizion System⁹⁷. *Campylobacter jejuni* ATCC 33560 was used as quality control organism. The MIC values obtained were compared with those of CLSI standards⁹⁸.

⁹⁴ ARIS™, Trek™ Diagnostic Systems Ltd, West Sussex, England.

⁹⁵ CLSI M100-S25.

⁹⁶ CLSI M45-A2.

⁹⁷ Sensititre Vizion System™, Trek™ Diagnostic Systems Ltd, West Sussex, England.

⁹⁸ CLSI M45-A2.

ANTIMICROBIAL SUSCEPTIBILITY BREAKPOINTS

Table 5. 2 Antimicrobial susceptibility breakpoints for *Salmonella* and *Escherichia coli*; CMV3AGNF plate, 2015

Antimicrobial	Range tested ($\mu\text{g/mL}$)	Breakpoints ^a ($\mu\text{g/mL}$)		
		S	I	R
Amoxicillin-clavulanic acid	1.0/0.5–32/16	$\leq 8/4$	16/8	$\geq 32/16$
I Ceftiofur ^b	0.12–8	≤ 2	4	≥ 8
Ceftriaxone	0.25–64	≤ 1	2	≥ 4
Ciprofloxacin	0.015–4	≤ 0.06	0.12–0.5	≥ 1
Ampicillin	1–32	≤ 8	16	≥ 32
Azithromycin ^c	0.12–16	≤ 16	N/A	≥ 32
Cefoxitin	0.5–32	≤ 8	16	≥ 32
II Gentamicin	0.25–16	≤ 4	8	≥ 16
Nalidixic acid	0.5–32	≤ 16	N/A	≥ 32
Streptomycin ^c	2–64	≤ 32	N/A	≥ 64
Trimethoprim-sulfamethoxazole	0.12/2.38–4/76	$\leq 2/38$	N/A	$\geq 4/76$
Chloramphenicol	2–32	≤ 8	16	≥ 32
III Sulfisoxazole	16–256	≤ 256	N/A	≥ 512
Tetracycline	4–32	≤ 4	8	≥ 16
IV				

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

S = Susceptible. I = Intermediate susceptibility. R = Resistant. N/A = Not applicable.

^a Unless otherwise specified, CLSI M100-S25 was the reference used for all antimicrobials in the panel.

^b CLSI VET-01-S2.

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

Table 5. 3 Antimicrobial susceptibility breakpoints for *Campylobacter*; CAMPY plate, 2015

Antimicrobial	Range tested ($\mu\text{g/mL}$)	Breakpoints ^a ($\mu\text{g/mL}$)		
		S	I	R
I Ciprofloxacin	0.015–64	≤ 1	2	≥ 4
Telithromycin ^b	0.015–8	≤ 4	8	≥ 16
Azithromycin ^b	0.015–64	≤ 2	4	≥ 8
Clindamycin ^b	0.03–16	≤ 2	4	≥ 8
II Erythromycin	0.03–64	≤ 8	16	≥ 32
Gentamicin ^b	0.12–32	≤ 2	4	≥ 8
Nalidixic acid ^b	4–64	≤ 16	32	≥ 64
III Florfenicol ^{b,c}	0.03–64	≤ 4	N/A	N/A
Tetracycline	0.06–64	≤ 4	8	≥ 16
IV				

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

S = Susceptible. I = Intermediate susceptibility. R = Resistant. N/A = Not applicable.

^a CLSI M45-A2.

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

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

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DATA ANALYSIS

HUMAN AND AGRI-FOOD SURVEILLANCE

DATA MANAGEMENT

Laboratory data from human and agri-food surveillance components originated in 2 computer programs (NML @ Winnipeg Labware and NML @ Guelph and NML @ Saint-Hyacinthe Labware) and were subsequently transferred to a central data repository using intermediary computer software⁹⁹. Data were then transferred to a SAS®-based harmonized database¹⁰⁰ called the Data Extraction and Analysis (DEXA) application. Additional antimicrobial resistance variables used for analysis were derived within the DEXA application; this application was also used as a central data access point.

RECOVERY RATE

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

RESISTANT ISOLATES

The percentage of isolates with resistance to one or more antimicrobials was defined as the number of isolates resistant to at least one antimicrobial divided by the total number of isolates tested for each antimicrobial, multiplied by 100.

The breakpoints used for interpretation of antimicrobial susceptibility results are listed in Table 5. 2 and Table 5. 3 (see the previous section). Intermediate Minimum Inhibitory Concentration (MIC) values were categorized as susceptible for all analyses. A new ceftriaxone breakpoint was officially adopted by the CLSI in January 2010 and was applied to all CIPARS data, including historical data. A new Enterobacteriaceae plate, CMV3AGNF, was utilized beginning in January 2014. Notable changes to the new plate included the removal of kanamycin (Category II) and expansion of the number of dilutions tested for streptomycin (Category II).

RESISTANCE PATTERNS

The total number of antimicrobials in each resistance pattern was calculated by summing the number of antimicrobials to which each isolate was resistant. The most common resistance pattern may include patterns with only 1 antimicrobial. In this case, like for the most common patterns including 2 or more antimicrobials, the number of isolates reported includes only those resistant to this specific pattern (i.e., without any additional resistance to other antimicrobials).

⁹⁹ Oracle®, Oracle Corp., Redwood Shores, CA, USA.

¹⁰⁰ SAS® 9.3, SAS Institute Inc., Cary, NC, USA.

STATISTICAL ANALYSIS

Data were analyzed with various statistical software¹⁰¹, and outputs were exported into a spreadsheet application¹⁰². All tables and figures were generated with the spreadsheet application.

For *Farm Surveillance*, statistical analyses were performed to account for clustering of antimicrobial resistance within swine herds or chicken flocks through generalized estimating equations (GEE)¹⁰³. All statistical models included a binary outcome, logit-link function, and exchangeable correlation structure. Null binomial response models were used to estimate the prevalence of resistance to each antimicrobial. From each null model, the intercept (β_0) and 95% confidence intervals were used to calculate population-averaged prevalence estimates with the formula $[1 + \exp(-\beta_0)] - 1$. When the prevalence was 0%, a model was run with a single positive isolate to determine the upper confidence interval only.

TEMPORAL ANALYSIS

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

- Resistance to the antimicrobial was absent or at a very low prevalence, or the breakpoint was debatable and other antimicrobials could be used to provide a surrogate measure of resistance or intermediate susceptibility (e.g., nalidixic acid for ciprofloxacin).
- The isolate was cross-resistant to another selected antimicrobial (e.g., amoxicillin-clavulanic acid and ceftiofur).
- The antimicrobial has been banned for use in the agri-food sector, and resistance to this drug is maintained because of the use of another/other antimicrobial(s) (e.g., chloramphenicol).

Logistic regression models (asymptotic or exact depending on prevalence of the outcome variable) were developed with year as an independent categorical variable. Data were analyzed with commercial software¹⁰⁴. *Farm Surveillance* data were adjusted for clustering at the herd level for grower-finisher pigs and flock level for broiler chickens. Components with regional or provincial temporal analysis had the current proportion of isolates resistant to a specific antimicrobial compared to those proportions observed in the previous surveillance year and 5 years previously. For broiler chickens, the 2015 data was compared to 2013 and 2014 data. For components with national temporal analysis, the current proportion of isolates resistant to a specific antimicrobial were compared to those proportions observed in the

¹⁰¹ SAS® 9.3; and Stata® 13 SE, Stata Corp., College Station, TX, USA.

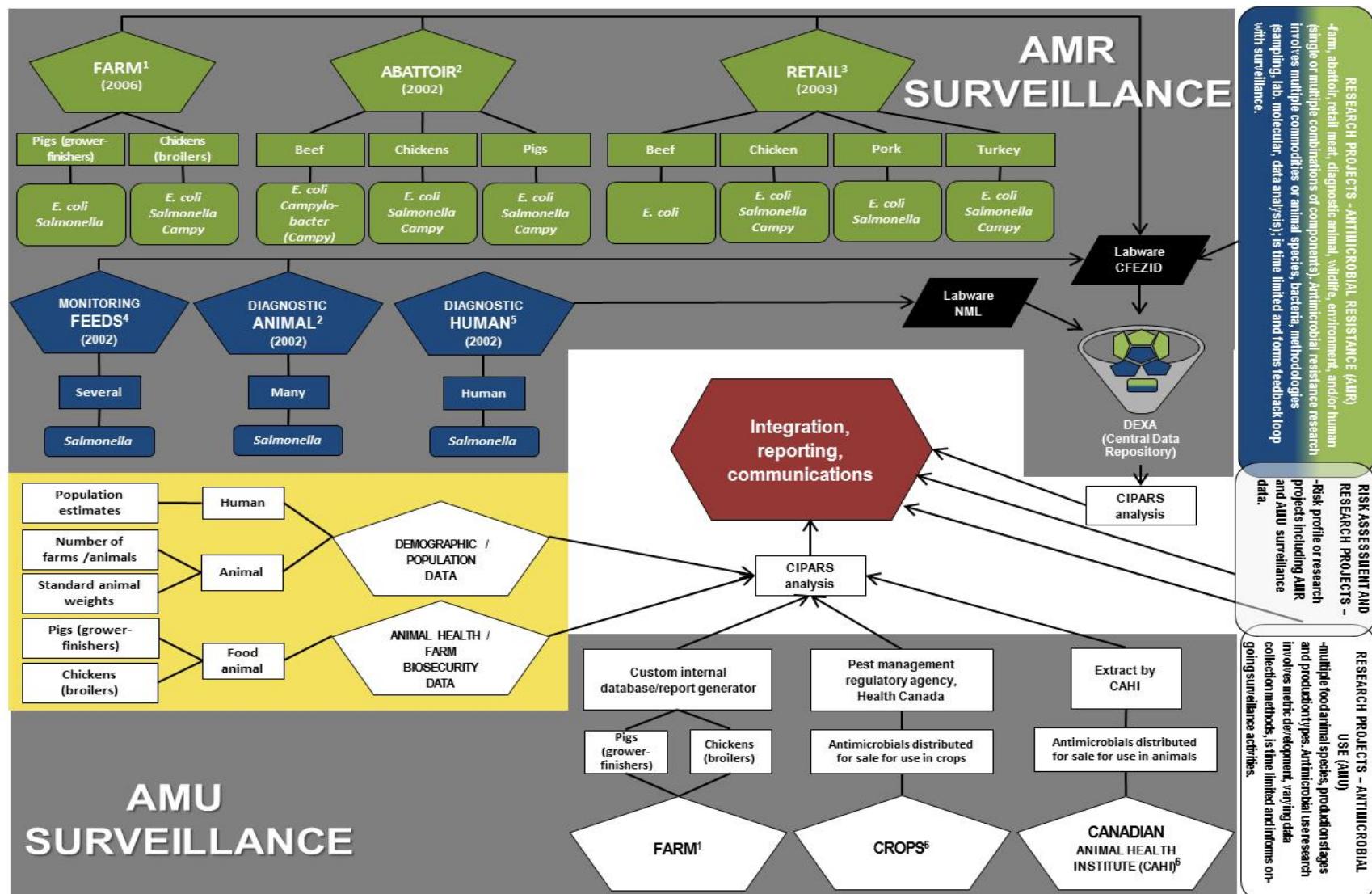
¹⁰² Microsoft® Excel 2010, Microsoft Corp.

¹⁰³ PROC GENMOD, SAS® 9.3.

¹⁰⁴ Stata® 13 SE.

previous surveillance year, 5 years previously (for comparison between components), and 10 years previously (or the first year of surveillance). In a few specific instances, the first comparison year may vary to reflect the implementation of new CIPARS components (e.g., 2006 for the *Farm Surveillance* component in grower-finisher pigs and addition of the broiler chicken *Farm Surveillance* component in 2013). For ampicillin and ceftiofur, special temporal analyses have been conducted for *E. coli* and *Salmonella* isolated from retail chicken or abattoir chickens to compare the current year's data with that of 2004 and 2006. This was due to a change in ceftiofur use practices by Québec chicken hatcheries in early 2005 and in 2007 (start and end of the voluntary period of withdrawal respectively). These special analyses were also conducted for human *Salmonella* Heidelberg isolates because this human serovar was suspected to originate from chicken. A *P*-value less than or equal to 0.05 was considered significant for all temporal analyses.

Figure 5.8 Summary of the CIPARS samples and data flow, 2015



See corresponding footnotes on the next page.

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= Active surveillance; primary data, primarily for prevalence estimation. = Passive surveillance; secondary data, primarily for AMR detection.
CFEZID = Centre for Food-borne, Environmental and Zoonotic Infectious Diseases. **NML** = National Microbiology Laboratory.

^{1–7} **CIPARS project leads:** 1—(grower-finisher pigs)—David Léger (david.leger@phac-aspc.gc.ca) and Sheryl Gow (sheryl.gow@phac-aspc.gc.ca); 1—(broiler chickens)—Agnes Agunos (agnes.agunos@phac-aspc.gc.ca); 2—Anne Deckert (anne.deckert@phac-aspc.gc.ca); 3—Brent Avery (brent.avery@phac-aspc.gc.ca); 4—Jane Parmley (jane.parmley@phac-aspc.gc.ca); 5—Michael Mulvey (michael.mulvey@phac-aspc.gc.ca); 6—Carolee Carson (carolee.carson@phac-aspc.gc.ca).

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ANTIMICROBIAL CLASSIFICATION

CATEGORIZATION OF ANTIMICROBIALS BASED ON IMPORTANCE IN HUMAN IMPORTANCE

Categories of antimicrobials used in this report were taken from the document Categorization of Antimicrobial Drugs Based on Importance in Human Medicine¹⁰⁵ by Health Canada's Veterinary Drugs Directorate (Table 5. 3). Antimicrobials are considered to be of Very High Importance in Human Medicine (Category I) when they are essential for the treatment of serious bacterial infections and there is no or limited availability of alternative antimicrobials for effective treatment. These antimicrobials include amoxicillin-clavulanic acid, ceftiofur¹⁰⁶, ceftriaxone, ciprofloxacin, and telithromycin. 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 antimicrobials of this category are generally susceptible to Category I antimicrobials, which could be used as alternatives. Antimicrobials of Medium Importance in Human Medicine (Category III) are used in the treatment of bacterial infections for which alternatives are generally available. Infections caused by bacteria resistant to these antimicrobials can, in general, be treated with Category II or I antimicrobials. Antimicrobials of Low Importance in Human Medicine (Category IV) are currently not used in human medicine.

¹⁰⁵ Health Canada. 2009. Categorization of Antimicrobial Drugs Based on Importance in Human Medicine. Version April, 2009. Available at: <https://www.canada.ca/en/health-canada/services/drugs-health-products/veterinary-drugs/antimicrobial-resistance/categorization-antimicrobial-drugs-based-importance-human-medicine.html>. Accessed July 2017.

¹⁰⁶ Ceftiofur is licensed for use in animals only. Resistance to ceftiofur is generally detected in combination with resistance to amoxicillin-clavulanic acid, cefoxitin, ampicillin and ceftriaxone (A2C-AMP-CRO resistance pattern).

Table 5. 4 Categorization of antimicrobial drugs based on importance in human medicine class, 2015

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) 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) Streptogramins Trimethoprim-sulfamethoxazole
III Medium importance	Aminocyclitols Aminoglycosides (topical agents) Bacitracins Fosfomycin Nitrofurans Phenicols Sulfonamides Tetracyclines Trimethoprim
IV Low importance	Flavophospholipols Ionophores

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

LIST OF ANTIMICROBIALS FROM THE FARM BROILER CHICKEN QUESTIONNAIRE

Table 5. 5 List of antimicrobials from the farm broiler chicken questionnaire database for each ATCvet class, 2015

ATCvet class	Antimicrobial
Antimicrobials administered via feed	
I Aminoglycosides, other (QJ01GB)	Neomycin (QJ01GB05) Apramycin (QJ01GB90)
I Lincosamides (QJ01FF)	Lincomycin (AJ01FF02)
I Lincosamides-aminocyclitol combinations (QJ01RA94)	Lincomycin-spectinomycin
II Macrolides (QJ01FA)	Erythromycin (QJ01FA01) Tylosin (QJ01FA90)
II Penicillins (QJ01RA)	Penicillin (QJ01RA01) Procaine benzylpenicillin (QJ01CE09) Virginiamycin (QJ01FG90)
II Streptogramins (QJ01FG)	Bacitracin (QA07AA93) Sulfamethazine (No ATCvet code)
III Sulfonamides, plain and in combination, intestinal (QP51AG)	Trimethoprim-sulfadiazine (No ATCvet code)
III Tetracyclines (QJ01AA)	Chlortetracycline (QJ01AA03) Oxytetracycline (QJ01AA06) Tetracycline (QJ01AA07)
IV Flavophospholipids Ionophores, agents against protozoal diseases (QP51A)	Bambermycin (No ATCvet code) Lasalocid (QP51AH02) Maduramicin (QP51AX10) Monensin (QP51AH03) Narasin (QP51AH04) Narasin-nicarbazin combination (QP51AH54) Salinomycin (QP51AH01)
V Arsenicals, agents against protozoal diseases (QP51AD)	4-nitrophenylarsonic acid (No ATCvet code)
V Chemical coccidiostats, other protozoal (QP51AX)	Amprolium (QP51AX09) Clopidol (No ATCvet code) Decoquinate (QP51AX14) Diclazuril (QP51AJ03) Nicarbazin (QP51AE03) Robénidine (QP51AX13) Zoalène/dinitolmide (QP51AX12) Avilamycin (No ATCvet code)
N/A Orthosomycin	

ATC = Anatomical Therapeutic Chemical.

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

N/A = not applicable (No classification available at the time of writing of this report).

The ATCvet system for classification of veterinary medicines is based on the same overall principles as the ATC system for substances used in human medicine. This system is a tool for exchanging and comparing data on drug use in veterinary medicine at international, national or local levels¹⁰⁷.

¹⁰⁷ World Health Organization Collaborating Center for Drug Statistics Methodology. ATCvet. Available at: www.whocc.no/atcddd. Accessed May 2017.

Table 5. 5 List of antimicrobials from the farm broiler chicken questionnaire database for each ATCvet class, 2015 (cont'd)

ATCvet class	Antimicrobial
Antimicrobials administered via drinking water	
I Fluoroquinolones	Enrofloxacin (QJ01MA90)
Aminoglycosides, other (QJ01GB)	Neomycin (QJ01GB05) Aframycin (QJ01GB90)
Lincosamides, combination with other antimicrobials	Lincomycin-spectinomycin (QJ01RA94)
Macrolides (QJ01FA)	Erythromycin (QJ01FA01) Tylosin (QJ01FA90)
II Penicillins, with extended spectrum (QJ01CA)	Amoxicillin (QJ01CA04)
Penicillins (QJ01RA)	Penicillin (QJ01RA90)
Penicillins, combination with other antibacterials (QJ01RA)	Penicillin-streptomycin (QJ01RA01)
Amphenicols (QJ01BA)	Florfenicol (QJ01BA90)
Sulfonamides, plain and in combination, intestinal (QP51AG)	Sulfamethazine (No ATCvet code) Sulfaquinoxaline (QP51AG03) Sulfaquinoxaline-pyrimethamine (No ATCvet code)
III Tetracyclines (QJ01AA)	Chlortetracycline (QJ01AA03) Oxytetracycline (QJ01AA06) Tetracycline (QJ01AA07)
Tetracyclines and combinations (QJ01RA90)	Oxytetracycline-neomycin (No ATCvet code) Tetracycline-neomycin (No ATCvet code)
Antimicrobials administered via subcutaneous or <i>in ovo</i> injections	
I Third-generation cephalosporins (QJ01DD)	Ceftiofur (QJ01DD90)
II Aminoglycosides, other (QJ01GB)	Gentamicin (QJ01GB03)
Lincosamides-aminocyclitol combinations (QJ01RA94)	Lincomycin-spectinomycin (No ATCvet code)

ATC = Anatomical Therapeutic Chemical.

N/A = not applicable (no classification available at the time of writing of this report).

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

The ATCvet system for classification of veterinary medicines is based on the same overall principles as the ATC system for substances used in human medicine. This system is a tool for exchanging and comparing data on drug use in veterinary medicine at international, national or local levels¹⁰⁸.

¹⁰⁸ World Health Organization Collaborating Center for Drug Statistics Methodology. ATCvet. Available at: www.whocc.no/atcddd. Accessed May 2017.

LIST OF ANTIMICROBIALS FROM THE FARM SWINE QUESTIONNAIRE

Table 5. 6 List of antimicrobials from the farm swine questionnaire database for each ATCvet class, 2015

ATCvet class	Antimicrobial
I Third-generation cephalosporins (QJ01DD)	Ceftiofur (QJ01DD90)
Fluoroquinolones	Enrofloxacin (QJ01MA90)
Amphenicols (QJ01BA)	Florfenicol (QJ01BA90)
Penicillins with extended spectrum (QJ01CA)	Ampicillin (QJ01CA01) Amoxicillin (QJ01CA04)
β-Lactamase sensitive penicillins (QJ01CE)	Penicillin (QJ01CE01)
Combination of sulfadoxine and trimethoprim (QJ01EW)	Trimethoprim-sulfadoxine (QJ01EW13)
Macrolides (QJ01FA)	Erythromycin (QJ01FA01) Tylosin (QJ01FA90) Tilmicosin (QJ01FA91) Tulathromycin (QJ01FA94)
II Lincosamides (QJ01FF)	Lincomycin (QJ01FF02)
Streptogramins (QJ01FG)	Virginiamycin (QJ01FG90)
Other aminoglycosides (QJ01GB)	Neomycin (QJ01GB05)
Combinations of antibacterials (QJ01RA)	Penicillin-streptomycin (QJ01RA01) Chlortetracycline-sulfamethazine-penicillin (QJ01RA90) Oxytetracycline-neomycin (QJ01RA90) Tetracycline-neomycin (QJ01RA90) Lincomycin-spectinomycin (QJ01RA94)
Other antibacterials (QJ01XX)	Spectinomycin (QJ01XX04)
Tetracyclines (QJ01AA)	Chlortetracycline (QJ01AA03) Oxytetracycline (QJ01AA06) Tetracycline (QJ01AA07)
III Sulfonamides (QJ01EQ)	Chlortetracycline, combinations (QJ01AA53) Combinations of sulfonamides (QJ01EQ30)
Pleuromutilins (QJ01XQ)	Tiamulin (QJ01XQ01)
Other antibacterials (QJ01XX)	Bacitracin (QJ01XX10)
IV No ATCvet code	Bambermycin (No ATCvet code)
Pyranes and hydropyranes (QP51AH)	Salinomycin (QP51AH01)

ATC = Anatomical Therapeutic Chemical.

Roman numerals I to IV indicate categories of importance to human medicine as outlined by the Veterinary Drugs Directorate.

The ATCvet system for classification of veterinary medicines is based on the same overall principles as the ATC system for substances used in human medicine. This system is a tool for exchanging and comparing data on drug use in veterinary medicine at international, national or local levels¹⁰⁹.

¹⁰⁹ World Health Organization Collaborating Center for Drug Statistics Methodology. ATCvet. Available at: www.whocc.no/atcddd. Accessed May 2017.



APPENDIX

ABBREVIATIONS

CANADIAN PROVINCES, TERRITORIES, AND REGIONS

PROVINCES

BC British Columbia

AB Alberta

SK Saskatchewan

MB Manitoba

ON Ontario

QC Québec

NB New Brunswick

NS Nova Scotia

PE Prince Edward Island

NL Newfoundland and Labrador

TERRITORIES

YT Yukon

NT Northwest Territories

NU Nunavut

REGIONS

Prairies: AB, SK, MB

Maritimes: NB, NS, PE

Atlantic: NB, NS, PE, NL

In 2015, not all provinces are represented in each surveillance component for the Prairies and the Atlantic region.

ANTIMICROBIALS

AMC Amoxicillin-clavulanic acid

AMP Ampicillin

AZM Azithromycin

CHL Chloramphenicol

CIP Ciprofloxacin

CLI Clindamycin

CRO Ceftriaxone

ERY Erythromycin

FLR Florfenicol

FOX Cefoxitin

GEN Gentamicin

NAL Nalidixic acid

SSS Sulfisoxazole

STR Streptomycin

SXT Trimethoprim-sulfamethoxazole

TEL Telithromycin

TET Tetracycline

TIO Ceftiofur

IMPORTANT RESISTANCE PATTERNS

A2C-AMP Amoxicillin-clavulanic acid, cefoxitin, ceftiofur, and ampicillin

ACSSuT Ampicillin, chloramphenicol, streptomycin, sulfisoxazole, and tetracycline

DISEASES

APP *Actinobacillus pleuropneumoniae*

APEC Avian pathogenic *Escherichia coli*

CAV Chicken Anemia Virus

IBDV Infectious Bursal Disease Virus

IBV Infectious Bronchitis Virus

PCVAD Porcine Circovirus Associated Disease

PRRS Porcine Reproductive and Respiratory Syndrome

TGE Transmissible gastroenteritis

OTHERS

G/TPD or g/TCD Grams per thousand pig-days or grams per thousand chicken-days

SSGF Single source grower-finisher

VDD Veterinary Drugs Directorate, Health Canada

SUMMARY OF DESIGN AND METHODS CHANGES

ANTIMICROBIAL USE

Table A. 1 Changes implemented to the CIPARS antimicrobial use components, 2003–2015

Year	Component	Province / region	Population exposed	Reporting metrics	Dosage information	Design	Methods
2015	<i>Farm AMU surveillance in pigs/chickens</i>	National Prairies Ontario Québec	Grover-finisher pigs/broiler chickens	1) DDDvetCA/PCU metric added to report.			
	<i>Quantities of antimicrobials distributed for sale for use in crops</i>	National	Crops		The 2014 data are reported in the 2016 Canadian Antimicrobial Resistance Surveillance System Report.		
	<i>Quantities of antimicrobials distributed for sale for use in animals</i>	National	Production animal (including horses) / companion animals	1) kg active ingredient stratified by route of administration. 2) mg/population correction unit for companion animal data.			Stratification of the data into route of administration by the Canadian Animal Health Institute (CAHI). Application of biomass denominator for the companion animal distribution data.
2014	<i>Farm AMU surveillance in pigs/chickens</i>	National Prairies Ontario Québec	Grover-finisher pigs/broiler chickens	1) mg active ingredient adjusted for population and weight. 2) median g of active ingredients/1,000 pig-days or 1,000 chicken-days. 3) Percentage of herds reporting antimicrobial use.			The CIPARS <i>Farm Surveillance</i> grover-finisher pig component began reporting regional and national antimicrobial use at the farm level. Two new metrics are used in grover-finisher pigs and broiler chickens to present data on antimicrobial use.
	<i>Human antimicrobial use surveillance</i>	National Provincial Regional	Canadians		Human antimicrobial use data no longer reported in CIPARS report.		
	<i>Quantities of antimicrobials distributed for sale for use in crops</i>	National	Crops		For the first time, Health Canada's Pest Management Regulatory Agency (PMRA) collects annual Canadian sales data from all pesticide manufacturers. Sales information on antimicrobial drugs registered as pesticides on food crops was provided by PMRA to CIPARS.		
2013	<i>Farm AMU surveillance in broiler chickens</i>	British Columbia Alberta Ontario Québec	Number of chicks placed and number of grown broilers (> 30 days of grow-out period)	Farm count data for AMU by class, category of importance to human medicine, and reason for use	Chick stage: inclusion rate in hatchery medications administered via in-ovo or subcutaneous. Broilers: inclusion rate in feed and water.	Implementation of the CIPARS farm component in broiler chickens of the 4 major poultry producing provinces.	Antimicrobial consumption estimates were based on the concentration of antimicrobials by tonnes of feed (or volume of water) over the duration of feed (or water) administration. Feed and water consumption estimates were based on current standards for the prevalent broiler strains.

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**Table A. 1 Changes implemented to the CIPARS antimicrobial use components, 2003–2015
(cont'd)**

Year	Component	Province / region	Population exposed	Reporting metrics	Dosage information	Design	Methods
2011	<i>Human antimicrobial use surveillance—physician diagnosis</i>	National Provincial Regional	Canadians	1) Total diagnoses/10,000 inhabitants 2) Total antimicrobial recommendations/10,000 inhabitants 3) Percentage diagnoses with antimicrobial recommendations		Enhancement of the <i>Human antimicrobial use surveillance</i> component. The design is based on a sample of physicians providing antimicrobial recommendation information for every patient in a 48-hour period four times a year.	Analysis based on the Canadian Disease and Therapeutic Index (CDTI) purchased from IMS Health Canada Inc.
	<i>Human antimicrobial use surveillance — hospital purchases</i>	National Provincial	Canadians	1) Defined Daily Doses (DDD)/1,000 inhabitant-days 2) Total cost/1,000 inhabitant-days 3) Total cost per unit of antimicrobials 4) Total active ingredient (kg)		Enhancement of the <i>Human antimicrobial use surveillance</i> component. The design is based on a purchasing information for a number of Canadian hospitals extrapolated to all hospitals in Canada.	Analysis based on the Canadian Drugstore and Hospital Purchases Audit (CDH) purchased from IMS Health Canada Inc.
	<i>Quantities of antimicrobials distributed for sale for use in animals</i>	National	A national animal biomass denominator was calculated as per the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)	1) Total of active ingredients (kg) (national and provincial; production animal, and companion animal); 2) mg/PCU (where PCU=population correction unit, a measure of animal biomass)			Stratification of CAHI data into production & companion animal; stratification by province; extraction of cephalosporins back into separate category; application of biomass denominator to national-level data.
2009	<i>Farm AMU surveillance in pigs</i>	Alberta Saskatchewan Manitoba Ontario Québec	Number of grower-finisher pigs at start and end of grow, mortalities and culls	Farm count data for antimicrobial use by class, category of importance to human medicine, and reason for use.	Inclusion rate in feed (g/tonne)	Annual and Sampling Day questionnaires were compiled into a single Sampling Day Questionnaire which is applied once/herd/year.	Inclusion rate in feed ONLY; no dosage information collected for water or injections.
2008	<i>Quantities of antimicrobials distributed for sale for use in animals</i>	National	N/A				CAHI has a "3 company accounting rule" to comply with the EU & the US' anti-competition regulations. CAHI added in some cases a "90% rule" to be sure not to infringe upon the regulations in the US. These accounting rules can result in changes to the categorization of specific antimicrobials over time.

N/A = not applicable.

**Table A. 1 Changes implemented to the CIPARS antimicrobial use components, 2003–2015
(cont'd)**

Year	Component	Province / region	Population exposed	Reporting metrics	Dosage information	Design	Methods
	<i>Human antimicrobial use surveillance—pharmacy sale</i>	National Provincial	Canadians	1) Prescriptions/1,000 inhabitants 2) Defined daily doses (DDDs)/1,000 inhabitant-days 3) Total cost/1,000 inhabitant-days 4) Total active ingredients (kg)			Data are now available separately for Newfoundland & Labrador and Prince Edward Island.
2007	<i>Farm AMU surveillance in pigs</i>	Alberta Saskatchewan Manitoba Ontario Québec	Number of grower-finisher pigs at start and end of grow, mortalities and culls	Farm count data for AMU by class, category of importance to human medicine, and reason for use.	Inclusion rate in feed and water (not collected for injections).		Questionnaire was refined to improve data quality and compliance.
	<i>Farm AMU surveillance in pigs</i>	Alberta Saskatchewan Manitoba Ontario Québec	Number of grower-finisher pigs at start and end of grow, mortalities and culls	Farm count data for AMU by class, category of importance to human medicine, and reason for use.	Inclusion rate in feed and water (not collected for injections).	Implementation of the CIPARS farm component in grower-finisher pigs of the 5 major porc producing provinces.	Antimicrobial use in feed, water, and injection information was collected through 1 annual and 3 sampling day questionnaires/herd/year.
2006	<i>Quantities of antimicrobials distributed for sale for use in animals</i>	National	N/A	1) Total of active ingredients (kg)	NA	Implementation of surveillance of manufacturer and distributor-level data for antimicrobials used in animals as provided by the Canadian Animal Health Institute (CAHI).	
2003	<i>Human antimicrobial use surveillance—pharmacy sale</i>	National	Canadians	1) Prescriptions/1,000 inhabitants. 2) Defined daily doses (DDDs)/1,000 inhabitant-days. 3) Total cost/1,000 inhabitant-days. 4) Total active ingredients (kg).		Implementation of the <i>Human antimicrobial use surveillance</i> component. The design is based on a number of canadian pharmacies dispensing oral prescriptions extrapolated to all pharmacies in Canada.	Analysis based on the Canadian CompuScript (CCS) purchased from IMS Health Canada Inc.

N/A = not applicable.

NA = not available.

ANTIMICROBIAL RESISTANCE

Table A. 2 Changes implemented to the CIPARS antimicrobial resistance components, 2002–2015

Year	Component	Province / region	Species	Selected bacteria				Design	Methods
				<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>		
2015	Retail Surveillance	British Columbia Prairies Ontario Québec	Beef	✓				Data was not collected in the Atlantic region due to budgetary constraints and partially collected in Ontario due to limited sampling technician availability.	Resistance to kanamycin is no longer reported due to its removal from the Enterobacteriace Gram-negative plate (CMV3AGNF). Additionally, the number of dilutions tested for streptomycin and sulfisoxazole were increased and decreased, respectively.
			Chicken	✓	✓	✓			
			Pork	✓					
			Turkey	✓	✓	✓			
2014	Retail Surveillance	British Columbia Prairies Ontario Québec Atlantic	Beef	✓				Data presented are stratified regionally (British Columbia, Prairies, Ontario, Québec, and Atlantic).	Resistance to kanamycin is no longer reported due to its removal from the Enterobacteriace Gram-negative plate (CMV3AGNF). Additionally, the number of dilutions tested for streptomycin and sulfisoxazole were increased and decreased, respectively.
			Chicken	✓	✓	✓			
			Pork	✓					
			Turkey	✓	✓	✓			
2014	Farm Surveillance	British Columbia Prairies Ontario Québec	Chickens	✓	✓	✓		Saskatchewan participated in the program; data aggregated with Alberta (Prairies).	Statistical analyses were limited to comparison of 2014 results for selected antimicrobials with: 1) 2013 results, 2) 2010 (or 5 years previous) for components with regional results (human, retail, and farm) and abattoir (for comparison between components) 3) the first year of surveillance for components (abattoir) with national results shown. The CIPARS Farm Surveillance grower-finisher pig component began reporting regional and national antimicrobial use at the farm level.
			Pigs	✓	✓				

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Table A. 2 Changes implemented to the CIPARS antimicrobial resistance components, 2002–2015 (cont'd)

Year	Component	Province / region	Species	Selected bacteria				Design	Methods
				<i>Escherichia coli</i>	Salmonella	Campylobacter	<i>Enterococcus</i>		
2013	Farm Surveillance	British Columbia Alberta Ontario Québec	Chickens	✓	✓	✓		Implementation of the CIPARS farm component in broiler chickens of the 4 major poultry producing provinces.	
		Alberta Saskatchewan Manitoba Ontario Québec	Pigs	✓	✓				
2012	Surveillance of Human Clinical Isolates	Across provinces	Humans		✓			Surveillance of <i>Salmonella</i> , <i>E. coli</i> and <i>Campylobacter</i> isolates in retail turkey was started in January.	Adoption of a lower breakpoint for ciprofloxacin ($\geq 1 \mu\text{g/mL}$; CLSI M100-S22) than in past years ($\geq 4 \mu\text{g/mL}$) for both <i>Salmonella</i> and <i>E. coli</i> . Ciprofloxacin's new breakpoint was applied to all data, including historical data. Then, the term "reduced susceptibility to ciprofloxacin" was dropped.
	Retail Surveillance	British Columbia Saskatchewan Ontario Québec Maritimes	Beef Chicken Pork	✓ ✓ ✓		✓			
2011	Abattoir Surveillance	Across provinces	Turkey	✓	✓	✓		Surveillance of <i>Campylobacter</i> in pigs at the abattoir was started in January.	
	Farm Surveillance	Alberta Saskatchewan Manitoba Ontario Québec	Beef cattle Chickens Pigs	✓ ✓ ✓		✓			
2010	Surveillance of animal clinical Isolates	Across provinces	Bovine Chickens Pigs Turkeys		✓ ✓ ✓ ✓				
	Feed and Feed Ingredients	Across provinces			✓				
2009	Surveillance of Human Clinical Isolates	Across provinces	Humans		✓			Human serovars : Newport added as a separate category.	The CMV2AGNF susceptibility testing plate has replaced the CMV1AGNF plate for <i>Salmonella</i> and <i>E. coli</i> . Amikacin was removed and azithromycin was included in the panel.
	Farm Surveillance	Alberta Saskatchewan Manitoba Ontario Québec	Pigs				✗	Bacterial culture and antimicrobial susceptibility testing of <i>Enterococcus</i> isolates from pigs were discontinued as of January.	

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Table A. 2 Changes implemented to the CIPARS antimicrobial resistance components, 2002–2015 (cont'd)

Year	Component	Province / region	Species	Selected bacteria				Design	Methods
				<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>		
2010	Retail Surveillance	British Columbia Saskatchewan Ontario Québec Maritimes	Humans		✓			Isolates classified as "Other serovars" category were not tested or reported, but stored for future AMR testing. Only the 7 serovars of interest had antimicrobial susceptibility testing.	Half of the <i>Salmonella</i> Enteritis submitted by the most populated provinces (British Columbia, Alberta, Ontario, and Québec) during the first 15 days of the month were tested.
			Beef	✓				Bacterial culture and antimicrobial susceptibility testing of <i>Enterococcus</i> in chicken isolates discontinued as of January (no vancomycin resistance was detected since the program began in 2003).	A new ceftriaxone breakpoint was officially adopted by the CLSI in January 2010. It was applied to all data, including historical data. A new genus- and species-specific multiplex PCR method was used in replacement of the standard method (biochemical tests) to perform identification and speciation of <i>Campylobacter</i> .
			Chicken	✓	✓	✓	✗		
	Abattoir Surveillance	Across provinces	Pork	✓					
			Beef cattle	✓		✓		Bacterial culture and antimicrobial susceptibility testing of <i>Campylobacter</i> isolates from abattoir chickens was initiated in January.	
			Chickens	✓	✓	✓			
			Pigs	✓	✓				
2009	Retail Surveillance	British Columbia Saskatchewan Ontario Québec Maritimes	Humans		✓			Human serovars: Newport not presented as a separate category; now included with the "other serovars".	
			Beef	✓				First full surveillance year in the Maritimes.	The CMV3AGPF susceptibility testing plate has replaced the CMV2AGPF plate for all <i>Enterococcus</i> isolates.
			Chicken	✓	✓	✓	✓		
	Farm Surveillance	Alberta Saskatchewan Manitoba Ontario Québec	Pork	✓					
			Pigs	✓	✓		✓	Sample collection from pigs on entry to the Grower-Finisher unit was terminated. Changed from 3 herd visits per year to 1 annual visit to collect fecal samples from close-to-market pigs.	
2008	Retail Surveillance	British Columbia Saskatchewan Ontario Québec Maritimes (pilot)	Humans		✓			Human serovars: Paratyphi A and B reported as a separate category along with Enteritidis, Heidelberg, Newport, Typhi, Typhimurium, and Other Serovars.	The ceftriaxone resistance breakpoint was changed to ≥ 4 µg/mL (CLSI M100-S20) for all <i>Salmonella</i> and <i>Escherichia coli</i> isolates. Quinupristin-dalfopristin was reclassified as Category II antimicrobial (High Importance in Human Medicine, Veterinary Drugs Directorate, Health Canada) for all <i>Enterococcus</i> isolates.
			Beef	✓				First surveillance year in British Columbia. Pilot surveillance also began in the Maritimes region in September 2008.	Application of a more sensitive <i>Campylobacter</i> recovery method in abattoir beef cattle isolates. Quinupristin-dalfopristin reclassified as category II for all <i>Enterococcus</i> isolates.
			Chicken	✓	✓	✓	✓		
	Farm Surveillance	Alberta Saskatchewan Manitoba Ontario Québec	Pork	✓					

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Table A. 2 Changes implemented to the CIPARS antimicrobial resistance components, 2002–2015 (cont'd)

Year	Component	Province / region	Species	Selected bacteria				Design	Methods	
				<i>Escherichia coli</i>	<i>Salmonella</i>	<i>Campylobacter</i>	<i>Enterococcus</i>			
2007	Retail Surveillance	British Columbia (pilot) Saskatchewan Ontario Québec	Beef	✓				Implementation of pilot retail surveillance in British Columbia.	Retail surveillance: Enhancement to the <i>Salmonella</i> recovery method yielded higher recovery rates than in prior years. For antimicrobial susceptibility testing of <i>Enterococcus</i> , bacitracin was removed and tigecycline removed from the panel. New resistance breakpoints were adopted for lincomycin (from ≥ 32 to ≥ 8 $\mu\text{g/mL}$) and kanamycin (from ≥ 512 to $\geq 1,024$ $\mu\text{g/mL}$).	
			Chicken	✓	✓	✓	✓			
	Surveillance of animal clinical Isolates		Pork	✓						
			Bovine		✓					
			Chickens		✓					
			Pigs		✓					
			Turkeys		✓					
	Feed and Feed Ingredients		Horses		✓			Publication of surveillance findings from clinical isolates from horses.		
			Not available		✓			Feed and Feed Ingredients presented as a separate surveillance component.		
2006	Retail Surveillance	Saskatchewan Ontario Québec	Beef	✓					The NARMS CAMPY plate has replaced the disk diffusion method (Etest) for antimicrobial susceptibility testing of <i>Campylobacter</i> .	
			Chicken	✓	✓	✓	✓			
			Pork	✓	✓					
	Abattoir Surveillance		Beef cattle	✓		✓		Abattoir surveillance of <i>Campylobacter</i> from beef cattle was started in January.		
			Chickens	✓	✓					
			Pigs	✓	✓					
	Farm Surveillance		Alberta Saskatchewan Manitoba Ontario Québec					Implementation of the CIPARS farm component in grower-finisher pigs of the 5 major pork producing provinces.		
			Pigs	✓	✓		✓			
2005	Retail Surveillance	Saskatchewan Ontario Québec	Beef	✓				Addition of Saskatchewan to the retail component.	Antimicrobial susceptibility testing of <i>Salmonella</i> and <i>E. coli</i> was fully performed by the NARMS CMV1AGNF plate in January.	
			Chicken	✓	✓	✓	✓			
			Pork	✓	✓					
	Abattoir Surveillance		Beef cattle	✓		✓		Pilot surveillance of <i>Campylobacter</i> from beef cattle started in late 2005.		
			Chickens	✓	✓					
			Pigs	✓	✓					
	Surveillance of Human Clinical Isolates		Humans		✓				Antimicrobial susceptibility testing of human <i>Salmonella</i> was performed by the NARMS CMV7CNCD from January to April and the CMV1AGNF from April to December.	
2004	Abattoir Surveillance	Across provinces	Beef cattle	✓	✗			Salmonella isolation discontinued because of its low prevalence in beef cattle.	There is a systematic rotational selection of extra lean, lean, regular, and medium ground beef.	
			Chickens	✓	✓					
			Pigs	✓	✓					
	Retail Surveillance		Beef	✓						
			Chicken	✓	✓	✓	✓			
			Pork	✓						

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Table A. 2 Changes implemented to the CIPARS antimicrobial resistance components, 2002–2015 (cont'd)

Year	Component	Province / region	Species	Selected bacteria				Design	Methods
				<i>Escherichia coli</i>	Salmonella	Campylobacter	Enterococcus		
	<i>Surveillance of Human Clinical Isolates</i>	Across provinces	Humans		✓			Implementation of the CIPARS human component. Antimicrobial susceptibility testing done on all serovars but they were classified and reported into the following categories: Enteritidis, Heidelberg, Newport, Typhi, Typhimurium, and Other Serovars.	Susceptibility testing of <i>Campylobacter</i> and <i>Enterococcus</i> was performed with the disk diffusion method using the ETest® methodology (AB Biodisk, Solna, Sweden) and the NARMS CMV5ACDC plate respectively.
2003	<i>Retail Surveillance</i>	Ontario Québec	Beef Chicken Pork	✓	✓	✓	✓	Implementation of the CIPARS <i>Retail Surveillance</i> component in Ontario and Québec.	
	<i>Surveillance of Human Clinical Isolates</i>	Across provinces	Humans					Agreement signed with the Provinces to send all (or a subset) of <i>Salmonella</i> isolates to CIPARS. Data were not available for reporting that year.	
2002	<i>Abattoir Surveillance</i>	Across provinces	Beef cattle Chickens Pigs Cattle Chickens Pigs Turkeys Feed and Feed Ingredients	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		Implementation of the first active surveillance component of CIPARS.	Antimicrobial susceptibility testing of <i>Salmonella</i> and <i>E. coli</i> was performed by the CMV7CNCD plate (Sensititre™), NARMS, United States.	
	<i>Surveillance of animal clinical Isolates</i>	Across provinces					Implementation of the first passive surveillance components of CIPARS.		

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SUPPLEMENTAL DATA

Table A. 3 Canadian Defined Daily Doses for animals (DDDvetCA) standard values for broiler chickens

Route of administration	European route of administration	Antimicrobial	Average dose basis	Average dose	DDDvetCA _{mg}	DDDmgCA _{broiler}
Feed	Oral	Amprolium	TP	159.2	20.7	20.7
		Avilamycin	TP	22.5	2.9	2.9
		Bacitracin	TP	77.9	10.1	10.1
		Bambermycin	GP	2.0	0.3	0.3
		Chlortetracycline	TP	128.3	16.7	16.7
		Clopidol	TP	125.0	16.3	16.3
		Decoquinate	TP	30.0	3.9	3.9
		Diclazuril	TP	1.0	0.1	0.1
		Zoalene (Dinitolmide)	TP	156.0	20.3	20.3
		Erythromycin	TP	220.0	28.6	28.6
		Halofuginone	TP	3.0	0.4	0.4
		Lasalocid	TP	102.5	13.3	13.3
		Maduramicin ammonium	TP	5.0	0.7	0.7
		Monensin	TP	100.0	13.0	13.0
		Narasin	TP	70.0	9.1	9.1
		Narasin-nicarbazin ^a	TP	40.0	5.2	5.2
		Nicarbazin	TP	132.5	17.2	17.2
		Nicarbazin-narasin ^a	TP	40.0	5.2	5.2
		Oxotetracycline	TP	128.3	16.7	16.7
		Penicillin G	GP	2.2	0.3	0.3
		Procaine penicillin G	TP	41.3	5.4	5.4
		Robenidine	TP	33.0	4.3	4.3
		Salinomycin	TP	60.0	7.8	7.8
		Semduramicin	TP	25.0	3.3	3.3
		Sulfadiazine-trimethoprim ^a (ELDU)	TP	83.3	10.8	10.8
Injectable	Parenteral	Trimethoprim-sulfadiazine ^a (ELDU)	TP	16.8	2.2	2.2
		Tylosin	TP	200.0	26.0	26.0
		Virginiamycin	TP	22.0	2.9	2.9
		Ceftiofur (ELDU)	TP	2.6	2.6	2.6
		Gentamicin	TP	10.8	10.8	10.8
		Lincomycin-spectinomycin ^a (ELDU)	TP	6.0	6.0	6.0
		Spectinomycin-lincomycin ^a (ELDU)	TP	12.0	12.0	12.0

Extra-label drug use (ELDU) in broiler chickens, dose, or doses were derived from expert opinion or veterinary consultations¹¹⁰. TP = Treatment and prevention. GP = Growth promotion. Supp = supplement or product has lower level of drug. Average dose = average of all doses indicated in available products listed in the Compendium of Medicating Ingredients Brochure¹¹¹ and Compendium of Veterinary Products¹¹²; values were multiplied to the standard values for either feed or water intake (see Table A.5) to obtain the DDDvetCA standard for broiler chickens. DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler ($\text{mg}_{\text{drug}}/\text{kg}_{\text{animal}}$).

^a Antimicrobials with hyphen is a combination drug; the values for this row pertain to the first drug in the sequence.

¹¹⁰ Canadian Association of Poultry Veterinarians. Available at: <http://www.capv-acva.ca/BroilerChicken.htm>. Accessed January 2017.

¹¹¹ CFIA, 2016b: Compendium of Medicating Ingredient Brochure. Available at: <http://www.inspection.gc.ca/animals/feeds/medicating-ingredients/eng/1300212600464/1320602461227>. Accessed on January 2017.

¹¹² Canadian Animal Health Institute, 2016: Compendium of Veterinary Products. Available at: <https://bam.naccvp.com/?u=country&p=msds>. Accessed on January 2017.

**Table A.3 Canadian Defined Daily Doses (DDDvetCA) standard values for broiler chickens
(cont'd)**

Route of administration	European route of administration	Antimicrobial	Average dose basis	Average dose	DDDvetCA _{mg}	DDDmgCA _{broiler}
Water	Oral	Amoxicillin	TP	52.0	12.0	12.0
		Apramycin (ELDU)	TP	100.0	23.0	23.0
		Amprolium	TP	240.0	55.2	55.2
		Enrofloxacin (ELDU)	TP	25.0	5.8	5.8
		Erythromycin	TP	86.7	19.9	19.9
		Lincomycin	TP	16.0	3.7	3.7
		Lincomycin-spectinomycin ^a	TP	277.5	63.8	63.8
		Neomycin	TP	94.8	21.8	21.8
		Oxytetracycline	TP	81.9	18.8	18.8
		Penicillin G	TP	178.3	41.0	41.0
		Penicillin G (supp)	TP	16.5	3.8	3.8
		Spectinomycin-lincomycin ^a	TP	555.0	127.7	127.7
		Streptomycin (supp)	TP	85.2	19.6	19.6
		Sulfamethazine	TP	1027.8	236.4	236.4
		Sulfaquinoxaline	TP	317.2	72.9	72.9
		Tetracycline	TP	93.1	21.4	21.4
		Tylosin	TP	312.5	71.9	71.9
		Sulfaquinoxaline-pyrimethamine ^a	TP	48.8	11.2	11.2
		Pyrimethamine-sulfaquinoxaline ^a	TP	14.7	3.4	3.4

Extra-label drug use (ELDU) in broiler chickens, dose/s were derived from expert opinion or veterinary consultations¹¹³. TP = Treatment and prevention. GP = Growth promotion. Supp = supplement or product has lower level of drug. Average dose = average of all doses indicated in available products listed in the Compendium of Medicating Ingredients Brochure¹¹⁴ and Compendium of Veterinary Products¹¹⁵; values were multiplied to the standard values for either feed or water intake (see Table A.5) to obtain the DDDvetCA standard for broiler chickens. DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram broiler (mg_{drug}/kg_{animal}).

^a Antimicrobials with hyphen is a combination drug; the values for this row pertain to the first drug in the sequence.

¹¹³ Canadian Association of Poultry Veterinarians. Available at: <http://www.capv-acva.ca/BroilerChicken.htm>. Accessed January 2017.

¹¹⁴ CFIA, 2016b: Compendium of Medicating Ingredient Brochure. Available at: <http://www.inspection.gc.ca/animals/feeds/medicating-ingredients/eng/1300212600464/1320602461227>. Accessed on January 2017.

¹¹⁵ Canadian Animal Health Institute, 2016: Compendium of Veterinary Products. Available at: <https://bam.naccvp.com/?u=country&p=msds>. Accessed on January 2017.

Table A. 4 Canadian Defined Daily Doses for animals (DDDvetCA) standard values for grower-finisher pigs

Route of administration	Antimicrobial	Average dose basis	Average dose	DDDvetCA (mg _{drug} /kg _{pig})
Feed	Bacitracin	TP	113.4	4.5
	Bambermycin	GP	0.0	0.0012
	Chlortetracycline	TP	260.3	10.4
	Lincomycin	TP	124.7	5.0
	Oxytetracycline	TP	189.4	7.6
	Penicillin	TP	51.6	2.1
	Salinomycin	GP	25.0	1.0
	Sulfamethazine	TP	110.0	4.4
	Tiamulin	TP	116.0	4.6
	Tilmicosin	TP	300.0	12.0
	Tylosin	TP	77.0	3.1
	Tylvalosin	TP	42.5	1.7
	Virginiamycin	TP	82.5	3.3
	Avilamycin	TP	80.0	3.2
	Lincomycin-spectinomycin ^a	TP	22.0	0.9
	Spectinomycin-lincomycin ^a	TP	22.0	0.9
	Narasin	GP	15.0	0.6
Injectable	Ampicillin	TP	6.0	6.0
	Ceftiofur	TP	3.0	3.0
	Enrofloxacin	TP	7.5	7.5
	Florfenicol	TP	7.5	7.5
	Gentamicin	TP	1.3	1.3
	Lincomycin	TP	10.0	10.0
	Oxytetracycline	TP	5.9	5.9
	Tiamulin	TP	11.0	11.0
	Tulathromycin	TP	2.5	2.5
	Tylosin	TP	5.5	5.5
	Benzathine	TP	1.2	1.2
	benzylpenicillin-combination ^a			
	Benzylpenicillin procaine	TP	11.2	11.2
	Benzylpenicillin procaine-combination ^a	TP	1.5	1.5
	Ceftiofur-long acting	TP	1.0	1.0
	Sulfadoxine-trimethoprim ^a	TP	13.3	13.3
	Trimethoprim-sulfadoxine ^a	TP	2.4	2.4
	Tulathromycin	TP	0.3	0.3

TP = Treatment and prevention. GP = Growth promotion. Supp = supplement or product has lower level of drug. Average dose = average of all doses indicated in available products listed in the Compendium of Medicating Ingredients Brochure¹¹⁶ and Compendium of Veterinary Products¹¹⁷; values were multiplied to the standard values for either feed or water intake (in Table A.6) to obtain the Canadian DDDvetCA standard values for pigs. DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram pig (mg_{drug}/kg_{animal}).

^a Antimicrobials with hyphen is a combination drug; the values for this row pertain to the first drug in the sequence.

¹¹⁶ CFIA, 2016b: Compendium of Medicating Ingredient Brochure. Available at: <http://www.inspection.gc.ca/animals/feeds/medicating-ingredients/eng/1300212600464/1320602461227>. Accessed on January 2017.

¹¹⁷ Canadian Animal Health Institute, 2016: Compendium of Veterinary Products. Available at: <https://bam.naccvp.com/?u=country&p=msds>. Accessed on January 2017.

Table A. 4 Canadian Defined Daily Doses for animals (DDDvetCA) standard values for grower-finisher pigs (cont'd)

Route of administration	Antimicrobial	Average dose basis	Average dose	DDDvetCA (mg _{drug} /kg _{pig})
Water	Amoxicillin	TP	200.0	20.0
	Lincomycin	TP	33.3	3.3
	Neomycin	TP	115.9	11.6
	Oxytetracycline	TP	146.4	14.6
	Penicillin G	TP	178.0	17.8
	Sulfamethazine	TP	789.7	79.0
	Sulfathiazole	TP	462.1	46.2
	Tetracycline	TP	85.9	8.6
	Tiamulin	TP	49.0	4.9
	Tylosin	TP	166.5	16.7
	Tylvalosin	TP	50.0	5.0
	Apramycin	TP	100.0	10.0
	Sulfamerazine (supp)	TP	32.9	3.3
	Sulfamethazine (supp)	TP	62.8	6.3
Bolus	Sulfathiazole (supp)	TP	103.0	10.3
	Sulfapyridine	TP	333.3	33.3
	Lincomycin-spectinomycin ^a	TP	44.4	4.4
	Spectinomycin-lincomycin ^a	TP	22.2	2.2
	Neomycin	TP		27.6
	Oxytetracycline	TP		30.4
	Spectinomycin	TP		18.8
	Sulfamethazine	TP		118.1
	Sulfathiazole	TP		57.4
	Sulfanilamide	TP		73.1

TP = Treatment and prevention. GP = Growth promotion. Supp = Supplement or product has lower level of drug. Average dose = Average of all doses indicated in available products listed in the Compendium of Medicating Ingredients Brochure¹¹⁸ and Compendium of Veterinary Products¹¹⁹; values were multiplied to the standard values for either feed or water intake (in Table A.6) to obtain the Canadian DDDvetCA standard values for pigs. DDDvetCA = Canadian Defined Daily Doses for animals (average labelled dose) in milligrams per kilogram pig (mg_{drug}/kg_{animal}).

^a Antimicrobials with hyphen is a combination drug; the values for this row pertain to the first drug in the sequence.

¹¹⁸ CFIA, 2016b: Compendium of Medicating Ingredient Brochure. Available at: <http://www.inspection.gc.ca/animals/feeds/medicating-ingredients/eng/1300212600464/1320602461227>. Accessed on January 2017.

¹¹⁹ Canadian Animal Health Institute, 2016: Compendium of Veterinary Products. Available at: <https://bam.naccvp.com/?u=country&p=msds>. Accessed on January 2017.

Table A. 5 Conversion factors for broiler chickens and other poultry

Standard values feed and water intake	Poultry
Canadian standard turkey poult weight (kg at hatch) ^a	0.06
Canadian standard chick weight (kg at hatch) ^a	0.042
Canadian standard broiler weight (kg) ^a	1.0
Canadian standard feed to weight ratio	0.13
Canadian standard water to weight ratio	0.23
ESVAC feed to weight ratio (kg feed/kg animal) ^b	0.13
ESVAC water to weight ratio (L water/kg animal) ^b	0.23

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

DDDA = Defined daily dose for animals.

^a As per expert opinion.

^b ESVAC Principles of DDDA Assignment¹²⁰.

Table A. 6 Conversion factors for swine

Standard values feed and water intake	Swine
Canadian standard piglet weight (kg)	4.00
Canadian standard grower-finisher pig weight (kg)	65.00
Canadian standard water intake (for a 65 kg pig) (L) ^a	6.50
Canadian standard feed intake (for a 65 kg pig) (kg)	2.18
Canadian standard feed to weight ratio	0.04
Canadian standard water to weight ratio	0.10
ESVAC Feed to weight ratio (kg feed/kg animal)	0.04
ESVAC Water to weight ratio (L water/kg animal)	0.10

ESVAC = European Surveillance of Veterinary Antimicrobial Consumption.

^a Water consumption estimation: Used 10% body weight to estimate. Alternatively could use formula : 0.788 + (2.23 x kg of daily feed intake) + [0.367 x kg pig body weight (0.06)]¹²¹.

¹²⁰ Available at:

http://www.ema.europa.eu/ema/index.jsp?curl=pages/includes/document/document_detail.jsp?webContentId=WC500184369&mid=WC0b01ac058009a3dc. Accessed January 2017.

¹²¹ Available at: http://www.sites.ext.vt.edu/newsletter-archive/livestock/aps-06_07/aps-349.html. Accessed on January 2017. Available at: http://www.sites.ext.vt.edu/newsletter-archive/livestock/aps-06_07/aps-349.html. Accessed on January 2017.