Report on the Japanese Veterinary Antimicrobial Resistance Monitoring System

2016–2017

National Veterinary Assay Laboratory

Ministry of Agriculture, Forestry and Fisheries

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Contents

1. Introduction

Antimicrobial agents are essential for maintaining the health and welfare of both animals and humans. However, their use has also been linked to the emergence and increasing prevalence of antimicrobial-resistant bacteria. In 1969, Swann reported on the transmission of antimicrobial-resistant bacteria, which had emerged as a consequence of the use of veterinary antimicrobial agents, to humans via livestock products, subsequently reducing the efficacy of these antimicrobial drugs in humans[1]. In addition, the development of antimicrobial resistance in these bacteria reduces the efficacy of veterinary antimicrobial drugs.

Antimicrobial agents have been used for the prevention, control, and treatment of infectious diseases in animals worldwide, and in some countries have also been used for non-therapeutic purposes in food-producing animals. The Japanese Veterinary Antimicrobial Resistance Monitoring System (JVARM) was established in 1999 in response to international concern regarding the impact of antimicrobial resistance on public and animal health[2]. Preliminary monitoring for antimicrobial-resistant bacteria was conducted in 1999 and the program has operated continuously since that time. However, although antimicrobial use for veterinary purposes represents a selective force promoting the emergence and increasing prevalence of antimicrobial-resistant bacteria in food-producing animals, these bacteria have also evolved in the absence of antimicrobial selective pressures.

In May 2015, the World Health Assembly endorsed the Global Action Plan on Antimicrobial Resistance[3] and urged all Member States to develop relevant national action plans within 2 years. Japan's "National Action Plan on Antimicrobial Resistance (AMR) 2016–2020" endorses the current status and monitoring of antimicrobial-resistant bacteria and national antimicrobial use as an important strategy for both evaluating the impact of the action plan on antimicrobial resistance and planning future national policy.

According to the national action plan, we have been strengthening our monitoring and have started monitoring among diseased companion animals. Moreover, in 2017, we also commenced the collection of data on the sales of human antimicrobial for use in animal clinics.

This report outlines the trends in antimicrobial resistance among indicator bacteria isolated from healthy food-producing animals and pathogenic bacteria isolated from diseased animals, including companion animals, as well as the volume antimicrobial sales over the 2-year period from 2016 to 2017, as assessed by the JVARM program.

2. The Japanese Veterinary Antimicrobial Resistance Monitoring System (JVARM)

2.1 Objectives

JVARM was set up to monitor the occurrence of antimicrobial-resistant bacteria in food-producing animals and the sales of antimicrobials for animal use. These objectives will contribute to determining the efficacy of antimicrobials in food-producing animals, encourage the prudent use of such antimicrobials, and enable us to ascertain the effects on public health.

2.2 Overview

JVARM includes the following three components. (1) monitoring the volume of the sale of antimicrobials for animal use, (2) monitoring antimicrobial resistance in zoonotic and indicator bacteria isolated from healthy animals, and (3) monitoring antimicrobial resistance in pathogens isolated from diseased animals (see Fig. 2.1). Until 2011, all bacteria assessed by this program were isolated from food-producing animals on farms. However, since 2012, samples have also been collected from slaughterhouses to increase the breadth of monitoring.

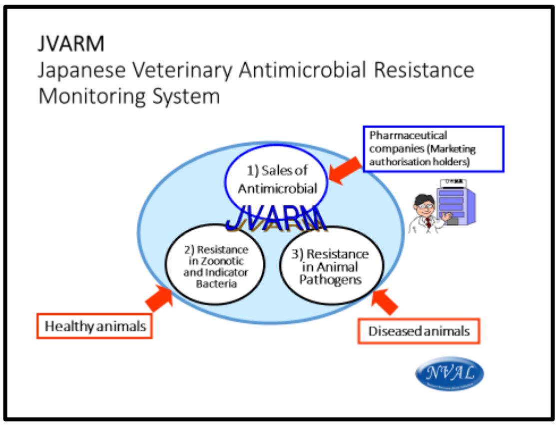


Fig. 2.1. Overview of JVARM.

(1) Monitoring of Antimicrobial Sales

The system that is currently used to monitor the volume of antimicrobial sales is shown in Fig. 2.2. Each year, marketing authorization holders of veterinary medical products (VMPs) are required to submit their sales data to the National Veterinary Assay Laboratory (NVAL) in accordance with "The Act on Securing Quality, Efficacy, and Safety of Pharmaceuticals, Medical Devices, Regenerative and Cellular Therapy Products, Gene Therapy Products, and Cosmetics (Law No.145, Series of 1960)." NVAL collates, analyzes, and evaluates these data, and then publishes them in an annual report, titled "Amount of medicines and quasi-drugs for animal use," on its website (http://www.maff.go.jp/nval/iyakutou/hanbaidaka/index.html).

Data on the weight (in kilograms) of the active ingredients in antimicrobial products that are sold annually for the treatment of animals are collected and then subdivided according to animal species. However, this method of analysis only provides an estimate of the volume of antimicrobial sales for each target species, as a single antimicrobial product is frequently used for multiple animal species.

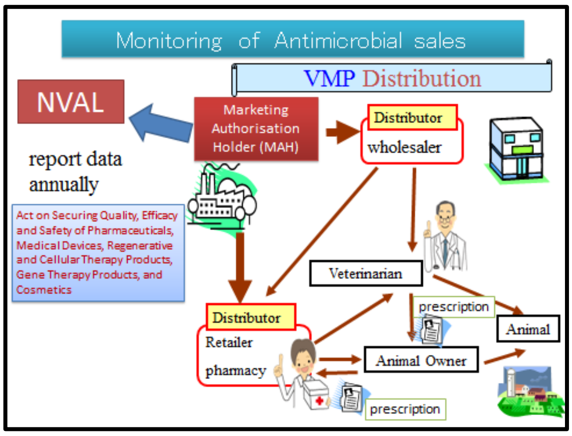


Fig. 2.2. Monitoring of antimicrobial sales

(2) Monitoring of Antimicrobial-resistant Bacteria

Zoonotic and indicator bacteria isolated from healthy animals and pathogenic bacteria isolated from diseased animals are continuously collected for antimicrobial susceptibility testing. Zoonotic bacteria include *Salmonella* species, *Campylobacter jejuni*, and *Campylobacter coli*; indicator bacteria include *Escherichia coli*, *Enterococcus faecium*, and *Enterococcus faecalis*; and animal pathogens include *Salmonella* species, *Staphylococcus* species, *E. coli*, *Mannheimia haemolytica*, and *Klebsiella pneumoniae*. Minimum inhibitory concentrations (MICs) of antimicrobial agents for target bacteria are then determined using the microdilution method, as described by the Clinical and Laboratory Standards Institute (CLSI)[4].

2.3 Implementation System

(1) Monitoring System for Farms with Diseased Animals

The JVARM monitoring system for bacterial strains isolated from diseased animals on farms is shown in Fig. 2.3. Animal pathogens that are designated by NVAL as target bacteria for a particular year are collected by Livestock Hygiene Service Centers (LHSCs) in each prefecture. The LHSCs isolate and identify certain types of pathogenic bacteria as part of their regular work, and send the bacteria to NVAL, which conducts MIC measurements and reports the results on its website (http://www.maff.go.jp/nval/yakuzai/yakuzai_p3.html).

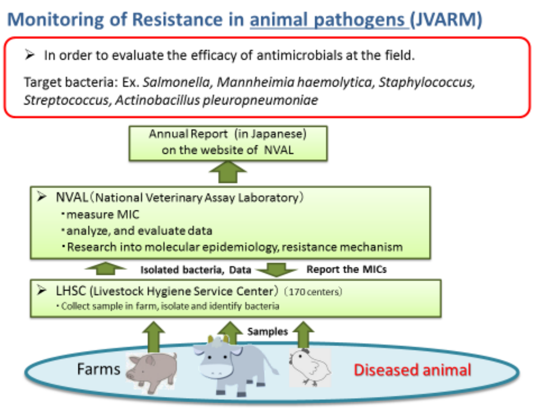


Fig. 2.3. The monitoring system used for diseased animals on farms

(2) Monitoring System for Slaughterhouses

The JVARM monitoring system

employed for slaughterhouses is shown in Fig. 2.4. Ministry of Agriculture, Forestry and Fisheries (MAFF) contracts the isolation, identification, and MIC measurement of target bacteria to private research laboratories. These laboratories send the results and tested bacteria to NVAL, which is responsible for preserving the bacteria, collating and analyzing all data, and reporting the findings to MAFF headquarters. Data collection and the preservation of *E. faecium* and *E. faecalis* are conducted at the Food and Agricultural Materials Inspection Center (FAMIC).

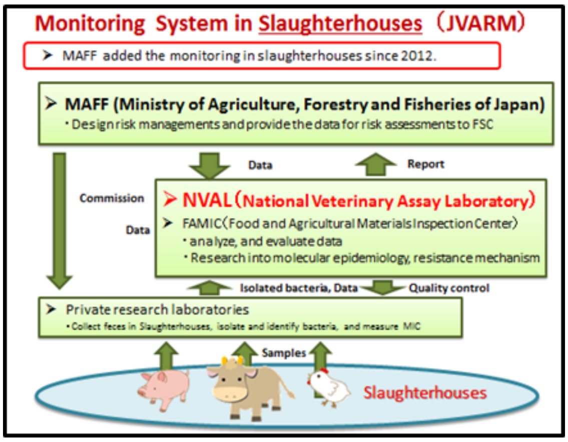


Fig. 2.4. The monitoring system used for slaughterhouses.

(3) Monitoring System for Companion Animals

Monitoring of diseased companion animals (dogs and cats) was inaugurated in 2017, as one of the measures designed to strengthen surveillance and monitoring according to the Japanese national action plan on antimicrobial resistance 2016–2020. The JVARM monitoring system for companion animals is shown in Fig. 2.5. The research laboratory contracted by MAFF collects target bacteria from cooperating private clinical laboratories. The contracted laboratory re-identifies the target bacteria, performs MIC determinations, and sends the results and tested bacterial strains to NVAL, which preserves the bacteria, collates and analyzes all the data, and reports the findings to MAFF headquarters.

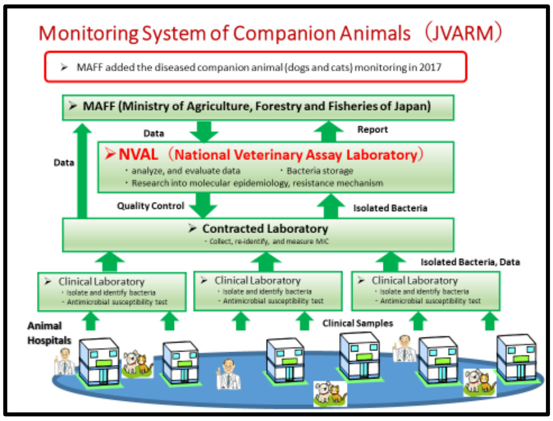


Fig. 2.5. The monitoring system used for companion animals.

2.4 Quality Assurance/Control Systems

Quality control is carried out at the participating laboratories that perform antimicrobial susceptibility testing to assist with monitoring of the precision and accuracy of the testing procedures, the performance of the reagents used, and the training of personnel involved. Strict adherence to standardized techniques is vital to ensure that the data collected are reliable and reproducible. Quality control reference bacteria are also tested in each participating laboratory to ensure standardization. Moreover, each year, NVAL holds a national training course for LHSC staff on antimicrobial resistance and standardized laboratory methods for the isolation, identification, and antimicrobial susceptibility testing of target bacteria. NVAL also undertakes inspections of the private research laboratories.

2.5 Publication of Data

Given that antimicrobial resistance affects both animal and human health, it is of paramount importance that information on antimicrobial resistance is distributed as rapidly as possible. NVAL officially publishes such information in scientific journals and on its website (http://www.maff.go.jp/nval/yakuzai/yakuzai_p3.html). Similarly, research conducted by NVAL on the molecular epidemiology and resistance mechanisms of bacteria is published in scientific journals (http://www.maff.go.jp/nval/yakuzai/pdf/jvarm_publications_list_20150916.pdf).

3. An Overview of the Availability of Veterinary Antimicrobial Products Used for Animal Therapy or as Antimicrobial Feed Additives in Japan

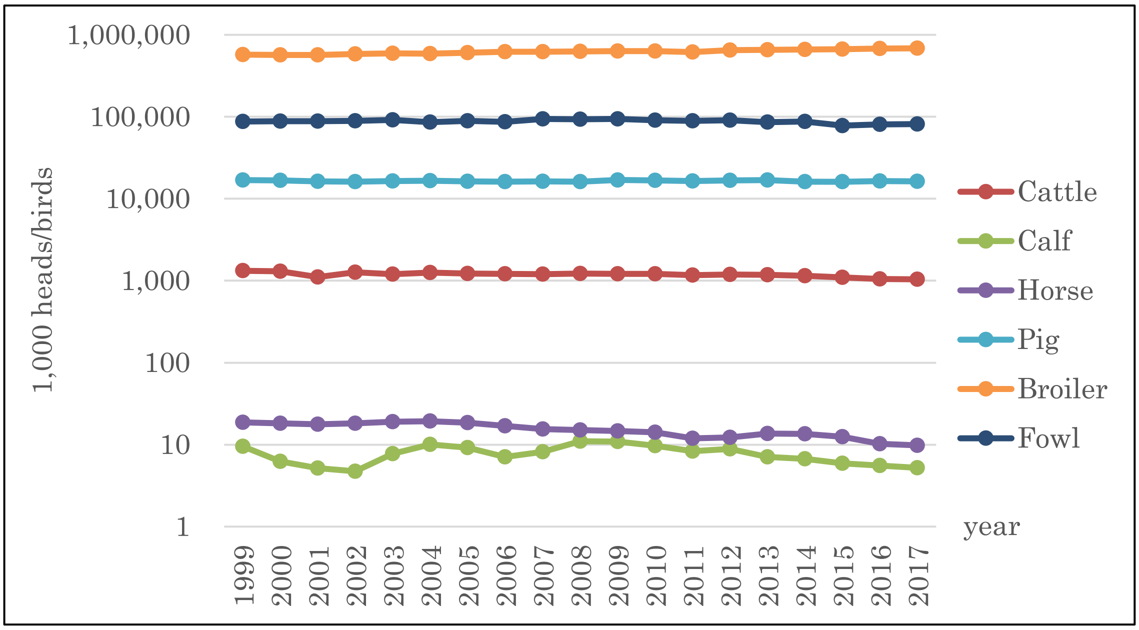
The numbers of animals that were slaughtered for meat in slaughterhouses and poultry slaughtering plants between 2015 and 2017 are shown in Table 3.1. There were no substantial changes in the number of meat-producing animals produced between 1999 and 2017 (Fig. 3.1). During this period, however, the number of individual farms underwent a continual reduction, whereas there was an increase in farm scale (data not shown).

Table 3.1. Numbers of animals (1,000 heads/birds) slaughtered in slaughterhouses and poultry slaughtering plants between 2015 and 2017

	Cattle	Calf	Horse	Pig	Broiler	Fowl*
2015	1,101.3	5.9	12.5	16,104.5	666,859	78,112
2016	1,045.8	5.5	10.2	16,392.0	677,332	80,984
2017	1,040.0	5.2	9.8	16,337.0	685,105	81,432

* Most of these birds were old layer chickens.

Fig. 3.1. Trends in the numbers of animals (1000 heads/birds) slaughtered in slaughterhouses and poultry slaughtering plants between 1999 and 2017.



Over the period between 2001 and 2017, the total volume of antimicrobial sales for animal use initially decreased and for a number of years fluctuated around 800 tons, but has more recently shown an upward trend (Fig. 3.2). Antimicrobials have tended to be used more frequently in pigs than in cattle or poultry (data not shown). In 2017, tetracyclines accounted for 40% of the total volume of sales in veterinary antimicrobials, whereas fluoroquinolones and cephalosporins each contributed to less than 1% of the total sales.

Antimicrobial feed additives were first used in Japan in the 1950s. Changes in the amount of feed additives (converted to bulk products) that were manufactured in Japan between 2003 and 2017 are shown in Fig. 3.3. The total volume manufactured between 2003 and 2009 averaged 170 tons, whereas from 2010 to 2017, there was an increase in volume to an average 199 tons, which was mainly attributable to an increase in the production of ionophores. Ionophores are widely used in the European Union and USA without prescription and comprised a large proportion of the feed additives [165 tons (81.1%)] used in 2017. In contrast, the amounts of polypeptides manufactured gradually fell to 15.2 tons (7.4%). Furthermore, the amounts of tetracyclines and macrolides manufactured tended to remain at low levels and the production of tetracyclines ceased in 2017.

Fig. 3.2. Volumes of veterinary antimicrobials (in tons of active ingredient) sold by pharmaceutical companies in Japan between 2001 and 2017.

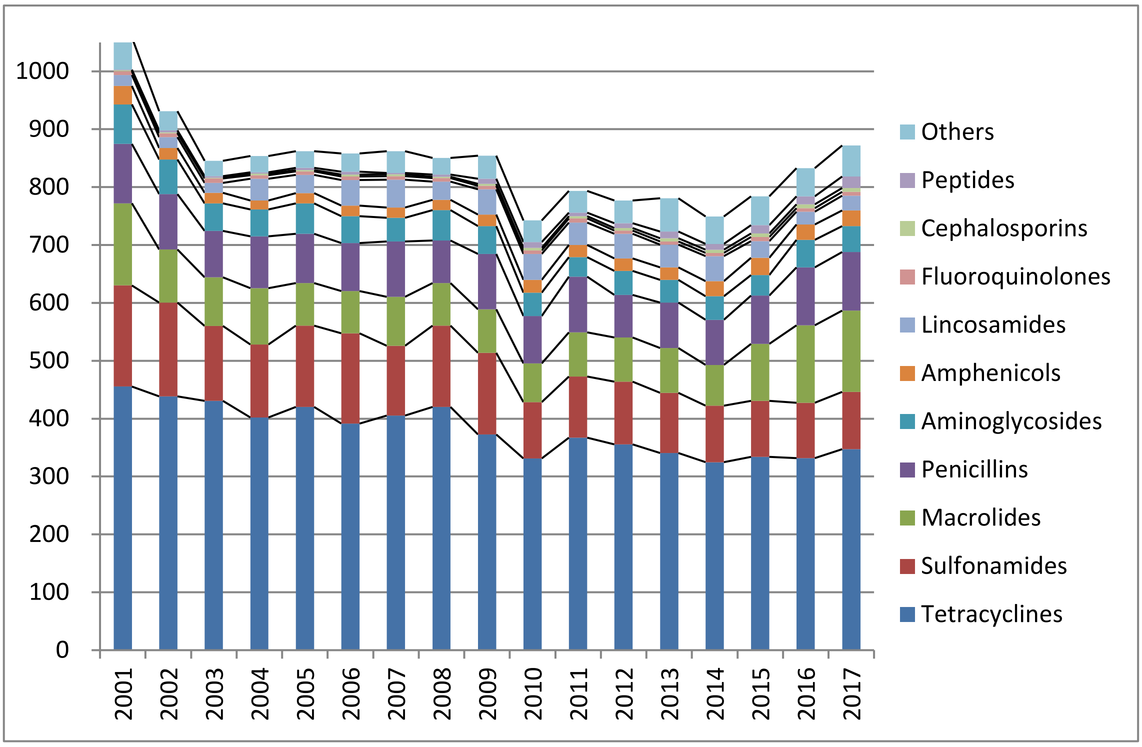
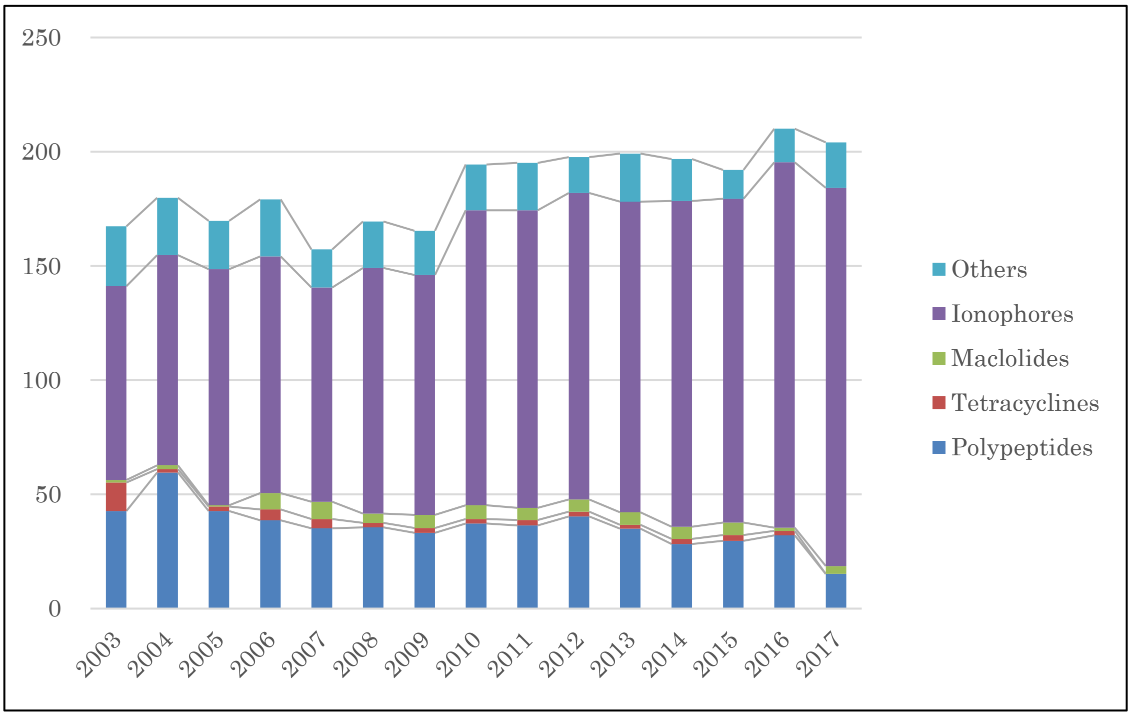
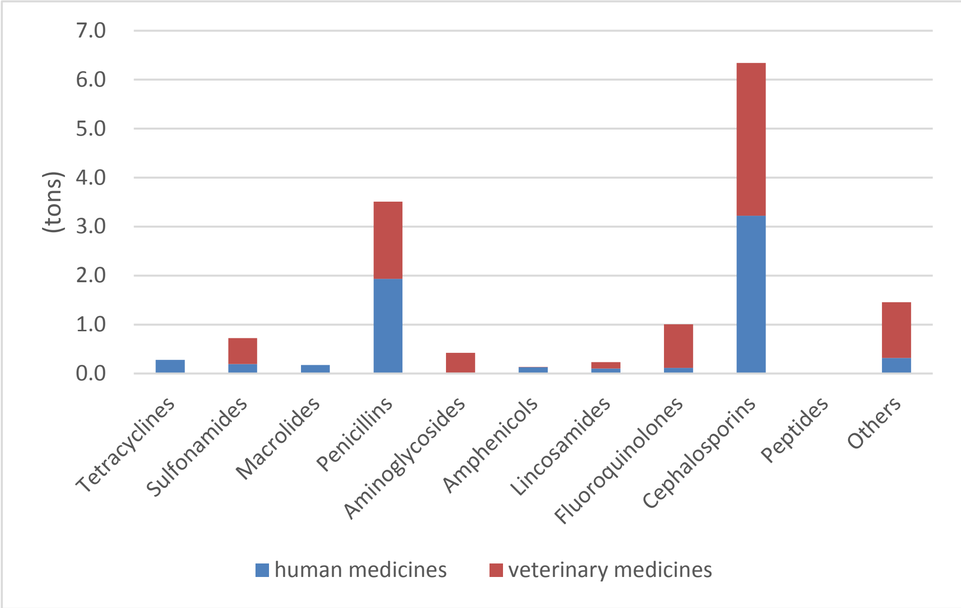


Fig. 3.3. Amounts of antimicrobial feed additives (in tons of active ingredient) manufactured in Japan between 2003 and 2017.



In many countries, veterinarians are permitted to prescribe human medicines, including antimicrobials, for treatment of animals under their responsibility. Human medicines are considered to be used primarily in companion animal hospitals. Accordingly, we collected data on human antimicrobials sales during 2016 for animal clinics. These data were provided by members of the Japan Animal Drug and Instrument Dealers Association and the Federation of Japan Pharmaceutical Wholesalers Association. The total amount of antimicrobials sold to companion animal hospitals was 6.48 tons, which is not substantially different from the sales of veterinary products (7.79 tons). In both human and veterinary medicines, the most frequently sold antimicrobials were cephalosporins followed by penicillins (Fig. 3.4). First- and second-generation cephalosporins accounted for 96.7% and 92.6% of total cephalosporins used in human and veterinary medicines, respectively.

Fig. 3.4. Amounts of human and veterinary antimicrobial medicines (in tons of active ingredient) sold for use in companion animals in 2016.



4. Monitoring of Antimicrobial Resistance in 2016 and 2017

4.1 Healthy Animals in Slaughterhouses

The total numbers of bacteria isolated from food-producing animals in slaughterhouses are shown in Table 4.1. All isolates were subjected to antimicrobial susceptibility testing.

(1) *Escherichia coli*

A total of 991 isolates of *E. coli* (510 from cattle, 173 from pigs, and 308 from broilers) collected in 2016 and 2017 were available for antimicrobial susceptibility testing, the MIC distributions of which are shown in Tables 12.1.1 and 12.1.2, respectively.

Among these isolates, there were high rates of resistance to streptomycin and tetracycline (19.0%–51.3% and 21.0%–56.7%, respectively).

In contrast, there were low rates of resistance to cefazolin/cefotaxime, gentamicin, ciprofloxacin, and colistin (0.4%–7.0%, 0.0%–6.0, 0.0%–4.4% and 0.4%–3.3%, respectively); one exception being ciprofloxacin-resistant *E. coli* isolated from chickens (10.1%–12.0%).

In general, *E. coli* isolates from pigs and broilers exhibited higher rates of resistance, which was most commonly against tetracycline (resistance rates in pigs and broilers of 55.4%–56.7% and 46.0%–56.3%, respectively), streptomycin (41.0%–50.0% and 41.3%–51.3%, respectively), ampicillin (33.7%–36.7% and 36.1%–39.3%, respectively), kanamycin (10.0%–10.8% and 36.7%–43.7%, respectively), nalidixic acid (12.0%–15.6% and 35.4%–39.3%, respectively), chloramphenicol (21.7%–25.6% and 11.3%–19.6%, respectively), and sulfamethoxazol/trimethoprim (26.5%–28.9% and 28.5%–34.7%, respectively).

Furthermore, there were significantly lower rates of resistance to tetracycline in *E. coli* isolated from cattle in 2017 compared with 2016 ($p < 0.05$) (Table 4.2).

(2) *Enterococcus*

A total of 959 isolates (481 from cattle, 173 from pigs. and 305 from broilers) of *Enterococcus* spp. were collected in 2016 and 2017. Among these, *E. faecalis* and *E. faecium* accounted for 3.7% (cattle) to 59.3% (broiler) and 1.7% (cattle) to 10.5% (broiler), respectively, and 235 *E. faecalis* and 58 *E. faecium* samples isolated from cattle, pigs, and broilers were subjected to antimicrobial susceptibility testing, the MIC distributions of which are shown in Tables 12.2.1, 12.2.2 and 12.3.1, 12.3.2, respectively.

Although neither of these bacterial species exhibited antimicrobial resistance against ampicillin, they were found to show resistance to the other antimicrobials tested. Rates of resistance varied according to both the bacterial and animal species, with bacteria isolated from pigs and broilers tending to show higher resistance than those isolated from cattle.

Isolates from pigs and broilers frequently exhibited resistance against oxytetracycline (resistance rates in *E. faecalis* and *E. faecium* of 65.9 %–84.6 % and 42.9%–60.0%, respectively), kanamycin (30.4%–58.8% and 28.6%–72.7%, respectively), erythromycin (52.2%–61.5% and 20.0%–57.1%, respectively), tylosin (52.2%–61.5% and 18.2%–28.6%), and lincomycin (55.3%–61.5% and 20.0%–28.6%, respectively) (Tables 4.3.1 and 4.3.2).

Resistance to enrofloxacin was found to be higher in *E. faecium* isolates (19.0% in 2016 and 18.9% in 2017) than in *E. faecalis* isolates (1.6% in 2016 and 0% in 2017). Resistance to enrofloxacin in *E. faecium* isolated from broilers was significantly lower in 2017 than in 2015 ($p < 0.05$), whereas resistance to dihydrostreptomycin in *E. faecalis* isolated from pigs and broilers was significantly lower in 2017 than in 2015 ($p < 0.05$) (Tables 4.3.1 and 4.3.2).

(3) *Campylobacter*

A total of 313 *C. jejuni* (178 from cattle and 135 from broilers) and 271 *C. coli* (147 from cattle, 100 from pigs, and 24 from broilers) collected in 2016 and 2017 were subjected to antimicrobial susceptibility testing. *C. jejuni* was isolated mainly from cattle and broilers, whereas *C. coli* was isolated more frequently from pigs. Their MIC distributions are shown in Tables 12.4.1–12.5.2.

The rates of resistance varied between bacterial species, and the resistance of *C. coli* against almost all antimicrobials tested was found to higher than that of *C. jejuni* isolates. Rates of resistance also tended to vary among animal species, with the highest levels of resistance against ampicillin, streptomycin, and tetracycline being detected in *C. coli* isolated from pigs.

For both *C. coli* and *C. jejuni*, resistance was most frequently observed against tetracycline (70.2%–80.0% and 49.7%–61.6%, respectively). Isolates of both species also exhibited resistance against ampicillin (resistance rates in *C. jejuni* and *C. coli* of 11.4%–16.5% and 7.8%–15.4%, respectively), streptomycin (3.0%–7.4% and 25.5%–37.7%, respectively), erythromycin (0%–0.6% and 17.0%–18.5%, respectively), chloramphenicol (3.4%–3.7% and 3.8%–8.5%, respectively), nalidixic acid (47.6%–51.0% and 65.4%–71.6%, respectively), and ciprofloxacin, (47.7%–48.2% and 67.7%–70.2%, respectively).

Resistance against ciprofloxacin was higher in *C. coli* isolated from cattle (75.0%–81.4%) and broilers (70.0%-71.4%) than in *C. coli* isolated from pigs (54.1%–59.0%) and *C. jejuni* isolated from broilers (44.8%–51.5%) and cattle (44.4%–50.5%). In addition, erythromycin and azithromycin resistance was frequently detected in *C. coli* isolated from pigs (31.1%–38.5% and 31.1%, respectively), but for *C. jejuni* was detected only in isolates from broilers.

Resistance to tetracycline in *C. jejuni* isolated from cattle was significantly higher in 2017 than in 2014 and 2015 ($p < 0.05$), and resistance to chloramphenicol in *C. jejuni* isolated from cattle was significantly higher in 2017 than in 2014 ($p < 0.05$) (Table 4.4).

(4) *Salmonella*

A total of 216 *Salmonella* isolates collected from broilers in 2016 and 2017 were available for antimicrobial susceptibility testing, the MIC distributions of which are shown in Tables 12.6.1 and 12.6.2.

The predominant serovars isolated from broilers were *S.* Schwarzengrund (149 isolates, 69.0%), *S.* Infantis (37 isolates, 17.1%), and *S.* Typhimurium (18 isolates, 8.3%) (Table 12.8).

The highest rates of resistance were observed for tetracycline (77.7%–82.7%), followed by kanamycin (72.1%–73.2%), streptomycin (60.7%–77.9%), trimethoprim/sulfamethoxazole (55.4%–56.7%), nalidixic acid (12.5%–17.0%), and ampicillin (8.0%–13.5%). In contrast, <5% of the isolates exhibited resistance against cefotaxime and chloramphenicol. Furthermore, the resistance of *Salmonella* isolates to streptomycin was significantly lower in 2017 than in 2014, 2015, and 2016 ($p < 0.05$) (Table 4.5).

Table 4.1. Total numbers of bacteria isolated from livestock in slaughterhouses between 2014 and 2017

Year	*E.coli*	*Enterococcus*	*Campylobacter*	*Salmonella*
2014	528	529	339	128
2015	554	546	415	123
2016	506	487	290	104
2017	485	472	294	112
Total	2073	2034	1338	467

Table 4.2. Antimicrobial resistance rates of *Escherichia coli* isolated from livestock in slaughterhouses between 2014 and 2017

Antimicrobials	Cattle				Pig				Broiler			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Ampicillin	3	5.5	7.4	4.8	43	34.4	36.7	33.7	40.1	43.5	36.1	39.3
Cefazolin	0	0	1.2	0.8	1.1	1.0	1.1	1.2	5.8	3.8	7.0	4.7
Cefotaxime	0	0	0.4	0.4	1.1	0	1.1	1.2	4.1	2.2	5.7	4.7
Streptomycin	17.1	12.4	22.1	19.0	52.7	39.6	50.0	41.0	44.8	41.8	51.3	41.3
Gentamicin	0	0	0.8	0	6.5	2.1	3.3	3.6	2.9	2.2	5.1	6.0
Kanamycin	0.4	0.7	4.3	1.2	9.7	8.3	10.0	10.8	33.1	37.5	43.7	36.7
Tetracycline	19.8	18.6	29.8	21.0[c]	59.1	45.8	56.7	55.4	43.6	54.9	56.3	46.0
Nalidixic acid	2.3	2.6	2.3	2.0	9.7	5.2	15.6	12.0	45.3	35.9	35.4	39.3
Ciprofloxacin	0.8	0	0.4	0.0	2.2	3.1	4.4	0.0	9.9	4.9	10.1	12.0
Colistin	0.8	0	0.4	0.8	0	0	1.1	0.0	0	0.5	1.9	0
Chloramphenicol	3.8	2.9	2.3	2.8	34.4	25.0	25.6	21.7	15.1	9.8	19.6	11.3
Trimethoprim-sulfamethoxazole	5.3	2.9	5.4	2.0	34.4	30.2	28.9	26.5	30.2	28.3	28.5	34.7

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

Table 4.3.1. Antimicrobial resistance rates of *Enterococcus faecalis* isolated from livestock in slaughterhouses between 2014 and 2017

Antimicrobials	Cattle				pig				Broiler			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Ampicillin	0	0	0	0	0	0	0	0	0	0.0	0	0
Dihydrostreptomycin	36.4	35.7	12.5	0	62.5	100.0	43.5	38.5[b]	53.8	72.4	40.6	38.8[b]
Gentamicin	27.3	0	0	0	12.5	15.4	8.7	7.7	9.9	14.3	6.3	3.5
Kanamycin	9.1	14.3	0	0	12.5	69.2	30.4	30.8	57.1	66.3	55.2	58.8
Oxytetracycline	27.3	28.6	37.5	10.0	87.5	92.3	73.9	84.6	67.0	70.4	83.3	65.9
Chloramphenicol	0	0	12.5	10.0	62.5	53.8	39.1	38.5	13.2	9.2	15.6	12.9
Erythromycin	9.1	0	0	10.0	62.5	69.2	52.2	61.5	64.8	60.2	59.4	58.8
Tylosin	0	0	0	10.0	62.5	69.2	52.2	61.5	65.9	53.1	59.4	60.0
Lincomycin	9.1	0	0	10.0	75.0	92.3	56.5	61.5	45.1	54.1	59.4	55.3
Enrofloxacin	0	0	0	0	0	7.7	0	0	1.1	0	2.1	0

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

Table 4.3.2. Antimicrobial resistance rates of *Enterococcus faecium* isolated from livestock in slaughterhouses between 2014 and 2017

Antimicrobials	Cattle				pig				Broiler			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Ampicillin	0	0	0	0	0	0	0	0	0	0	0	0
Dihydrostreptomycin	33.3	0	25.0	0	58.3	0	28.6	27.3	13.9	16.1	30.0	18.2
Gentamicin	0	0	0	0	0	0	0.0	0.0	2.8	3.2	10.0	9.1
Kanamycin	33.3	16.7	0	50.0	25	72.7	28.6	72.7	33.3	35.5	40.0	45.5
Oxytetracycline	0	16.7	0	0	41.7	9.1	42.9	54.5	58.3	64.5	60.0	31.8
Chloramphenicol	0	0	0	0	25	0	0	9.1	8.3	6.5	0	9.1
Erythromycin	0	33.3	25.0	0	58.3	54.5	57.1	45.5	30.6	35.5	20.0	27.3
Tylosin	0	0	0	0	16.7	0	28.6	18.2	19.4	22.6	20.0	27.3
Lincomycin	0	0	0	0	50	9.1	28.6	27.3	19.4	29.0	20.0	27.3
Enrofloxacin	0	16.7	25.0	0	25	0	0	27.3	13.9	71.0	30.0	18.2[b]

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

Table 4.4. Antimicrobial resistance rates of *Campylobacter* species isolated from livestock in slaughterhouses between 2014 and 2017

Antimicrobials	Cattle				Pig				Broiler			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Ampicillin	12.9	8.9	7.4	8.2	36.6	24.6	15.4	29.5	17.5	19.1	16.2	28.4
Streptomycin	3.8	3.2	6.2	4.1	69.9	72.3	64.1	68.9	3.5	2.1	8.8	1.5
Erythromycin	0	1.3	0.0	0	43	26.2	38.5	31.1	0	0	0	1.5
Tetracycline	49.2	52.2	63.0	72.2[ab]	80.6	87.7	89.7	83.6	38.6	28.7	33.8	46.3
Nalidixic acid	50.8	42.7	45.7	48.5	52.7	47.7	61.5	50.8	29.8	27.7	57.4	46.3
Ciprofloxacin	49.2	40.8	44.4	50.5	50.5	47.7	59.0	54.1	29.8	26.6	51.5	44.8
Chloramphenicol	0	1.3	3.7	6.2[a]	7.5	9.2	15.4	1.6	1.8	0	2.9	0.0

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

Table 4.5. Antimicrobial resistance rates of *Salmonella* species isolated from livestock in slaughterhouses between 2014 and 2017

Antimicrobials	Broiler			
	2014	2015	2016	2017
Ampicillin	17.2	13.0	13.5	8.0
Cefazolin	3.1	1.6	7.7	3.6
Cefotaxime	2.3	1.6	1.9	1.8
Streptomycin	85.9	76.4	77.9	60.7[abc]
Gentamicin	0	0	0	0
Kanamycin	57.8	69.1	72.1	73.2
Tetracycline	85.2	83.7	82.7	77.7
Nalidixic acid	17.2	15.4	12.5	17.0
Ciprofloxacin	0	0	0	0
Colistin	0	0	0	0
Chloramphenicol	1.6	1.6	0	0.9
Trimethoprim-sulfamethoxazole	51.6	57.7	56.7	55.4

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

4.2 Diseased Animals on Farms

(1) *Salmonella*

A total of 229 *Salmonella* isolates (129 from cattle and 100 from pigs) collected in 2016 and 2017 were available for antimicrobial susceptibility testing, the MIC distributions of which are shown in Tables 12.7.1 and 12.7.2, respectively.

The predominant serovars were *S.* Typhimurium (79 isolates, 34.5%), which was predominant among pig isolates (46/100, 46.0%), O4:i:- (59 isolates, 25.8%), which was predominant in cattle isolates (36/129, 27.9%), and *S.* Infantis (18 isolates, 7.9%), which was predominant in cattle isolates (15/129, 11.6%) (Table 12.8).

In general, *Salmonella* isolated from cattle and pigs had the highest rates of resistance, which was most commonly against tetracycline (resistance rates in cattle and pigs of 39.0%–42.9% and 50.0%–58.9%, respectively) and ampicillin (40.7%–50.0% and 40.9%–41.1%, respectively). Resistance against cefazolin was found to be higher in 2016 compared with 2015 on account of the resistance breakpoint being changed from 32 µg/mL to 8 µg/mL (resistance rates in cattle and pigs of 22.9% and 23.2%, respectively). However, the rates of resistance to cefazolin in cattle and pigs isolates in 2017 were significantly lower than those in 2016 ($p < 0.05$). The rate of resistance to chloramphenicol in cattle was significantly lower than in 2015 ($p < 0.05$). Furthermore, the *Salmonella* isolated from cattle in 2017 showed significantly lower resistance to kanamycin than those isolated in 2015 and 2016 ($p < 0.05$), and isolates from cattle and pigs exhibited low rates of resistance to cefotaxime, colistin, and ciprofloxacin (0%–5.1%)（Table 4.6）.

(2) *Staphylococcus aureus*

Among *S. aureus* isolates, the highest rates of resistance were observed for ampicillin (3.7%–75.6%) followed by tetracycline (0%–57.8%), erythromycin (1.7%–38.8%), and streptomycin (0%–33.3%) (Table 4.7).

(3) *Escherichia coli*

Among *E. coli* isolates, the highest rates of resistance were observed for tetracycline (54.5%–87.3%) followed by streptomycin (38.9%–74.5%), ampicillin (33.3%–74.5%) and chloramphenicol (11.1%–69.6%) (Table 4.8).

Table 4.6. Antimicrobial resistance rates (%) of *Salmonella* isolates from 2014 to 2017 in the Japanese Veterinary Antimicrobial Resistance Monitoring System (JVARM) program

Antimicrobials	Cattle				Pig			
	2014	2015	2016	2017	2014	2015	2016	2017
Ampicillin	61.9	56.6	50.0	40.7	41.4	46.9	41.1	40.9
Cefazolin	7.9	7.9	22.9	5.1[c]	0	6.1	23.2	6.8[c]
Cefotaxime	8	7.9	4.3	1.7	0	4.1	0	0
Gentamicin	3.2	7.9	4.3	1.7	15.5	8.2	17.9	15.9
Kanamycin	14.3	21.1	25.7	5.1[bc]	8.6	6.1	10.7	13.6
Tetracycline	50.8	55.3	42.9	39.0	60.3	61.2	58.9	50.0
Chloramphenicol	17.5	22.4	12.9	3.4[b]	25.9	12.2	8.9	18.2
Colistin	0.0	0.0	1.4	5.1	0	0	3.6	4.5
Nalidixic acid	3.2	11.8	5.7	5.1	15.5	6.1	7.1	9.1
Ciprofloxacin	0	0	0	1.7	0	0	3.6	4.5
Trimethoprim-sulfamethoxazole	6.3	13.2	4.3	3.4	32.8	22.4	21.4	25.0

a: Significantly different compared with 2014
b: Significantly different compared with 2015
c: Significantly different compared with 2016
: Significantly increased
: Significantly decreased

Table 4.7. Proportion (%) of antimicrobial-resistant *Staphylococcus aureus* isolated from diseased animals in 2016 and 2017

Antimicrobials	BP	2016			2017		
		Cattle n=141	pig n=45	chicken n=27	Cattle n=174	pig n=49	chicken n=31
Ampicillin	0.5	7.8	75.6	3.7	7.4	71.4	22.6
Tetracycline	16	0	57.8	33.3	0	53.1	19.4
Gentamicin	16	0	2.2	3.7	0.6	14.3	9.7
Streptomycin	64	1.4	33.3	3.7	3.4	20.4	0
Erythromycin	8	2.8	37.8	22.2	1.7	38.8	6.5
Ciprofloxacin	4	0.7	11.1	3.7	0.6	8.2	3.2
Chloramphenicol	32	0	22.2	3.7	0.6	30.6	3.2

Table 4.8. Proportion (%) of antimicrobial-resistant *Escherichia coli* isolated from diseased animals in 2016 and 2017

Antimicrobials	BP	2016			2017		
		Cattle n=77	Pig n=102	Chicken n=46	Cattle n=90	pig n=123	Chicken n=36
Ampicillin	32	37.7	74.5	43.5	50	70.7	33.3
Cefazolin	8	15.6	34.3	15.2	15.6	35.0	11.1
Cefotaxime	4	7.8	2.9	6.5	8.9	3.3	5.6
Streptomycin	32	49.4	74.5	56.5	61.1	72.4	38.9
Gentamicin	16	10.4	21.6	10.9	8.9	22.8	5.6
Kanamycin	64	16.9	46.1	50.0	26.7	39.0	36.1
Tetracycline	16	54.5	87.3	78.3	62.2	78.9	55.6
Nalidixic acid	32	18.2	48	56.5	33.3	50.4	55.6
Ciprofloxacin	4	11.7	24.5	8.7	17.8	28.5	11.1
Colistin	4	10.4	56.9	8.7	20.0	52.0	0
Chloramphenicol	32	19.5	69.6	21.7	28.9	59.3	11.1
Trimethoprim	16	23.4	62.7	23.9	35.6	56.9	13.9

4.3 Companion Animals

The monitoring of diseased companion animals (dogs and cats) was commenced in 2017, with *E. coli*, *Enterococcus* spp., coagulase-positive *Staphylococcus* spp., *Klebsiella* spp., *Enterobacter* spp., and *Acinetobacter* spp. samples being collected from clinical laboratories. The total numbers of bacteria isolated from companion animals are shown in Table 4.9. All isolates were subjected to antimicrobial susceptibility testing.

(1) *Escherichia coli*

A total of 335 *E. coli* isolates (199 from dogs and 136 from cats) were collected in 2017, the MIC distributions of which are shown in Tables 12.9.1 and 12.9.2.

The resistance of *E. coli* isolated from dogs and cats were found to show a similar pattern (Table 4.10). For both species, there were high rates of resistance against ampicillin and quinolones (nalidixic acid and ciprofloxacin) (dogs: 55.3%, 61.8%, and 43.2%; cats: 64.0%, 58.8%, and 39.0%, respectively). In contrast, resistance to gentamicin (14.1% and 12.5% in dogs and cats, respectively), chloramphenicol (12.6% and 13.2%, respectively), and kanamycin (6.5% and 8.1%, respectively) were relatively low, and with the exception of one colistin-resistant strain isolated from a dog, no strains showing resistance against colistin or meropenem were isolated.

(2) *Enterococcus*

A total of 229 *Enterococcus* spp. isolates (131 from dogs and 98 from cats) were collected in 2017, the species and strain numbers of which are shown in Table 4.9. The MIC distributions of *E. faecalis* and *E. faecium* isolates are shown in Tables 12.10.1, 12.10.2 and 12.11.1, 12.11.2, respectively.

Among the *Enterococcus* spp. isolated from dogs and cats, *E. faecalis* was the most frequently encountered (90 from dogs and 72 from cats). There was a similar tendency with respect to the isolates obtained from dogs and cats (Tables 4.11). For both animal species, there was only a single ampicillin-resistant strain. In contrast, high rates of resistance to tetracycline were detected (70.0% in dogs and 72.2% in cats), followed erythromycin (53.3% in dogs and 36.1% in cats), whereas for other antimicrobials (chloramphenicol, ciprofloxacin and gentamicin) rates of resistance of approximately 20% were detected among strains isolated form dogs and cats.

E. faecium strains isolated from dogs and cats were also found to show similar resistance tendencies, although these differed from those identified for *E. faecalis* (Tables 4.11–4.12). The rates of resistance against ciprofloxacin were very high (100.0% in dogs and 94.7% in cats). In contrast to *E. faecalis,* there were also high rates of resistance for ampicillin (93.1% in dogs and 84.2% in cats), and there were also relatively high rates of resistance against erythromycin, tetracycline, and gentamicin (31.0%–79.3% in dogs and 42.1%–63.2% in cats), whereas resistance rates for chloramphenicol were typically low (6.9% in dogs and 5.3% in cats).

(3) *Staphylococcus pseudintermedius*

A total of 205 coagulase-positive *Staphylococcus* spp. isolates (133 from dogs and 72 from cats) were collected in 2017, the species and strain numbers of which are shown in Table 4.9.

S. pseudintermedius (122 and 51 isolates from dogs and cats, respectively) was the most commonly detected *Staphylococcus* spp., the MIC distributions of which are shown in Tables 12.12.1 and 12.12.2. The resistance rates of *S. pseudintermedius* strains isolated from dogs and cats showed similar patterns (Table 4.13). In dogs, isolates showed highest resistance against erythromycin and azithromycin (both 67.2%), followed ciprofloxacin (64.8%), whereas in cats, the highest rates of resistance were detected for ciprofloxacin were highest (88.2%), followed by erythromycin (70.6%). In both dogs and cats, the lowest rates of resistance were those for gentamicin (26.2% and 13.7% in dogs and cats, respectively). Resistance against other drugs ranged from 43.4% to 62.3% in dogs and 52.9% to 68.6% in cats. Although methicillin-resistant *S. pseudintermedius* (MRSP) is considered a major cause for concern in small animal clinics, we also detected high rates of resistance to oxacillin (58.2% in dogs and 68.6% in cats).

(4) *Klebsiella pneumoniae*

A total of 104 *Klebsiella* spp. isolates (77 from dogs and 27 from cats) were collected in 2017, including 86 isolates of *K. pneumoniae* (62 from dogs and 24 from cats), 12 of *K. oxytoca* (10 from dogs and 2 from cats), and 6 of *K. aerogenes* (formerly *Enterobacter aerogenes*; 5 from dogs and 1 from cat).

Among the *Klebsiella* spp. isolated, *K. pneumoniae* was the most commonly encountered, the MIC distributions of which are shown in Tables 12.13.1 and 12.13.2. The rates of resistance shown by *K. pneumoniae* were found to be relatively high, particularly those against cephalosporins (48.4%–51.6% in dogs and 87.5% in cats) and quinolones (48.4%–54.8% in dogs and 87.5% in cats). However, with the exception of a single colistin-resistance strain derived from a cat, no strains showing resistance against colistin or meropenem were detected. Apart from chloramphenicol, the resistance rates of strains isolated from cats tended to be higher than those isolated from dogs.

(5) *Enterobacter* and *Acinetobacter*

In 2017, 26 *Enterobacter cloacae*

isolates (13 from dogs and 13 from cats) and 16 *Acinetobacter* spp. isolates (8 from dogs and 8 from cats) were recorded, among the latter of which, there were 13 isolates of *A. baumaninii/calcoaceticus* (7 from dogs and 6 from cats) and 3 isolates of *A. radioresistens* (1 from a dog and 2 from cats).

Given the relatively small number of isolates, the results obtained from the antimicrobial susceptibility tests conducted for these isolates are not shown.

Table 4.9. Number of bacteria isolated from diseased companion animals in 2017

Species	Dogs	Cats	Total
E. coli	199	136	335
Enterococcus	131	98	229
E. faecalis	90	72	162
E. faecium	29	19	48
E. gallinarum	10	5	15
E. avium	1	0	1
E. casseliflavus	1	0	1
E. durans	0	2	2
Staphylococcus	133	72	205
S. pseudintermedius	122	51	173
S. aureus	6	21	27
S. shleiferi subsp. *coagulans*	4	0	4
S. intermedius	1	0	1
Klebsiella	77	27	104
Enterobacter	13	13	26
Acinetobacter	8	8	16

Table 4.10. Antimicrobial resistance rates (%) of *Escherichia coli* isolated from diseased companion animals in 2017

Antimicrobials	Dogs	Cats
Ampicillin	55.3	64.0
Cefazolin	31.2	37.5
Cefalexin	31.7	41.9
Cefotaxime	26.1	33.8
Meropenem	0	0.0
Streptomycin	29.6	32.4
Gentamicin	14.1	12.5
Kanamycin	6.5	8.1
Tetracycline	28.1	24.3
Nalidixic acid	61.8	58.8
Ciprofloxacin	43.2	39.0
Colistin	1.0	0.0
Chloramphenicol	12.6	13.2
Sulfamethoxazole/Trimethoprim	24.6	22.1

Table 4.11. Antimicrobial resistance rates (%) of *Enterococcus faecalis* isolated from diseased companion animals in 2017

Antimicrobials	Dogs	Cats
Ampicillin	1.1	1.4
Gentamicin	18.9	13.9
Tetracycline	70.0	72.2
Erythromycin	53.3	36.1
Chloramphenicol	24.4	23.6
Ciprofloxacin	18.9	18.1

Table 4.12. Antimicrobial resistance rates (%) of *Enterococcus faecium* isolated from diseased companion animals in 2017

Antimicrobials	Dogs	Cats
Ampicillin	93.1	84.2
Gentamicin	31.0	42.1
Tetracycline	51.7	57.9
Erythromycin	79.3	63.2
Chloramphenicol	6.9	5.3
Ciprofloxacin	100.0	94.7

Table 4.13. Antimicrobial resistance rates (%) of *Staphylococcus pseudintermedius* isolated from diseased companion animals in 2017

Antimicrobial agent	Dogs	Cats
Oxacillin	58.2	68.6
Gentamicin	26.2	13.7
Tetracycline	62.3	52.9
Erythromycin	67.2	70.6
Azithromycin	67.2	66.7
Ciprofloxacin	64.8	88.2
Chloramphenicol	43.4	64.7

Table 4.14. Antimicrobial resistance rates (%) of *Klebsiella pneumoniae* isolated from diseased companion animals in 2017

Antimicrobials	Dogs	Cats
Cefazolin	51.6	87.5
Cefalexin	51.6	87.5
Cefotaxime	48.4	87.5
Meropenem	0.0	0.0
Streptomycin	29.0	58.3
Gentamicin	29.0	62.5
Kanamycin	8.1	25.0
Tetracycline	37.1	58.3
Nalidixic acid	54.8	87.5
Ciprofloxacin	48.4	87.5
Colistin	0.0	4.2
Chloramphenicol	27.4	25.0
Sulfamethoxazole/Trimethoprim	46.8	83.3

5. JVARM Topics

5.1 Prevalence of the colistin resistance genes *mcr-1* and *mcr-5* in *Escherichia coli* and *Salmonella* isolated from healthy food-producing animals in Japan

Colistin is currently considered the last-resort antibiotic for the treatment of infections caused by multidrug-resistant gram-negative bacteria in humans worldwide. For more than 50 years, this antibiotic has also been used as a veterinary drug for the treatment of gram-negative gastrointestinal infections and as a feed additive to promote healthy development in food-producing animals. Until recently, the mechanism underlying colistin resistance in bacteria was believed to involve only chromosomal mutations; however, in 2015, Liu *et al.*[5] reported a plasmid-mediated colistin resistance gene, *mcr-1*, in *Enterobacteriaceae* isolated from food-producing animals, retail meat, and humans in China.

As part of the JVARM program, a total of 9,860 *E. coli* isolates from healthy animals (3,350 from cattle, 2,159 from swine, 2,127 from broilers, and 2,224 from layers) were screened for colistin resistance between 2000 and 2015. For isolates obtained between 2000 and 2009, colistin MICs were determined using the agar dilution method, whereas the broth dilution method was used for isolates obtained between 2010 and 2015, in accordance with the recommendations of CLSI. In total, 753 (7.6%) of the isolates were found to have colistin MICs of ≥2 mg/L, and were thus examined for the presence of the two colistin resistance genes *mcr-1* and *mcr-2* by polymerase chain reaction (PCR), as described by Liu *et al.*[5] and Xavier *et al.*[6], respectively.

Very few colistin-resistant isolates were detected between 2000 and 2015 [MIC > 2 mg/L following the criteria of the European Committee of Antimicrobial Resistance Testing (EUCAST), and even with the inclusion of isolates in which MIC = 2 mg/L, there has been no increase in the proportion of colistin-resistant and reduced-susceptibility isolates of *E. coli* since 2008, when *mcr-1* was first detected.

mcr-1 was detected in 50 strains (5, 28, and 17 strains isolated from cattle, swine, and broilers, respectively), whereas *mcr-2* was not detected in any isolates. Although the prevalence of *mcr-1* in *E. coli* strains isolated from healthy animals has increased slightly over the years, it has continued to remain at very low levels.

The JVARM program has also involved the screening *E. coli* isolates from slaughterhouses and poultry processing plants for colistin resistance, with a total of 3,283 isolates (1,636 from cattle, 684 from swine, and 963 from broilers) being screened for resistance between 2012 and 2017. Among these isolates, 83 (3%) had colistin MICs of ≥2 mg/L, and were thus examined for the presence of the five colistin resistance genes *mcr-1* to *mcr-5* via PCR[7].

Very few colistin-resistant isolates were detected between 2012 and 2017 (MIC > 2 mg/L following the EUCAST criteria), and even with the inclusion of isolates for which the MIC = 2 mg/L, there has been no increase in the proportion of colistin-resistant and reduced-susceptibility isolates of *E. coli* since 2012.

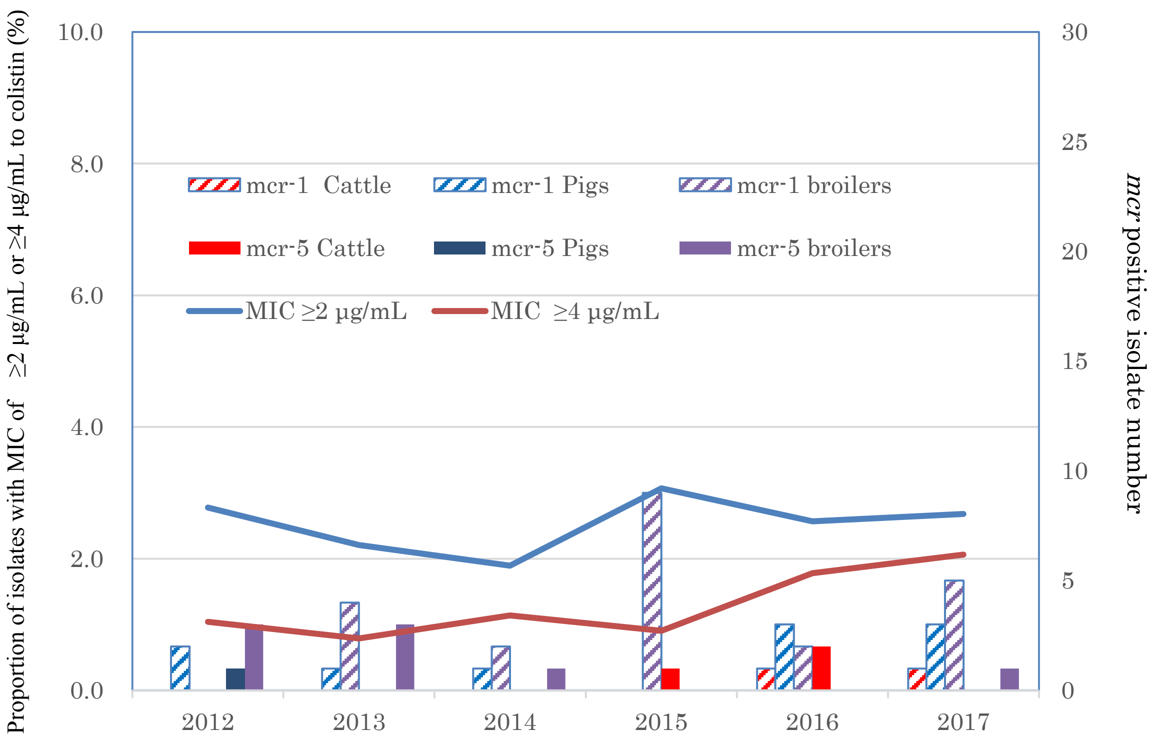
mcr-1 was detected in 34 strains (2, 10, and 22 strains isolated from cattle, swine, and broilers, respectively), whereas *mcr-5* was detected in 12 strains (3, 1, and 8 strains isolated from cattle, swine and broilers, respectively). The prevalence of *mcr-1* in *E. coli* isolated from healthy animals has increased slightly over the years, although has remained at a very low level (Fig. 5.1).

A total of 725 *Salmonella* isolates from poultry processing plants were screened for colistin resistance between 2012 and 2017 as part of the JVARM program. In total, 173 (23.9%) of the isolates had colistin MICs of ≥2 mg/L, and were thus examined for the presence of the five colistin resistance genes *mcr-1* to *mcr-5* via PCR[7].

No colistin-resistant isolates were detected between 2012 and 2017 (MIC > 2 mg/L, following the EUCAST criteria), and no *mcr* genes were detected in these *Salmonella* strains.

In Japan, risk management measures are implemented according to the extent of risk, as determined by risk assessment with regards to the impact of antimicrobial-resistant bacteria on human health through the consumption of food. Risk management options for colistin in livestock animals are currently being promoted in Japan and include enhanced monitoring of antimicrobial-resistant bacteria, the restriction of colistin to second-choice drug status, and the revocation of its designation as a feed additive. Continuous surveillance and monitoring, and ensuring the prudent use of antibiotics in veterinary medicine, are essential for preventing or reducing the transfer of resistant bacteria or resistance determinants to humans, animals, food, and the environment.

Fig. 5.1. Proportions of *Escherichia coli* isolates with different susceptibilities to colistin and the number of *mcr*-positive isolates obtained from healthy food-producing animals between 2012 and 2017, as assessed by the Japanese Veterinary Antimicrobial Resistance Monitoring System (JVARM) program. MIC, minimum inhibitory concentration.



5.2 Prevalence of *bla*$_{CMY-2}$-positive plasmids in *Escherichia coli* isolated from healthy broilers in Japan

Third-generation cephalosporins (3GCs) are used as therapeutic agents for the treatment of infectious bacterial diseases in humans, and are deemed to be of critical importance by the World Health Organization (WHO). The emergence of 3GC-resistant bacteria in food-producing animals is thus a global public health concern, owing to the potential for transmittance to human via animal products. Extended-spectrum β-lactamases (ESBLs) and AmpC enzymes are known to hydrolyze 3GCs, and the plasmid-derived AmpC β-lactamase gene, *bla*$_{CMY-2}$ has been regularly detected in 3GC-resistant *E. coli* strains isolated from healthy broilers.

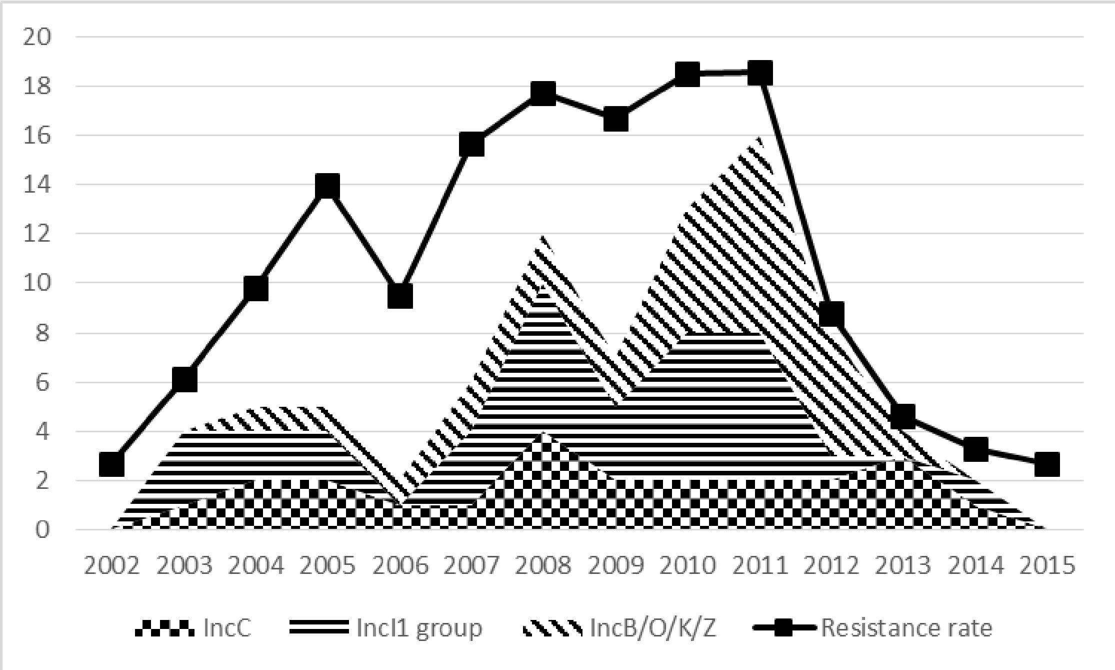
As part of the JVARM program, a

total of 1,866 *E. coli* isolates were collected from fecal samples of healthy broiler chickens housed on different farms in different prefecture between 2002 and 2015. Between 2002 and 2009, MICs for the 3GC ceftiofur were determined for isolates using the agar dilution method according to the recommendations of CLSI, whereas the broth dilution method was used for isolates obtained between 2010 and 2015. From among the screened *E. coli* isolates, 135 showing 3GC resistance were used for whole-genome sequence analysis. Prior to sequencing, S1 nuclease linerization–pulsed field gel electrophoresis was performed to separate the plasmid and chromosomal DNAs of the 135 isolates using the method described by Barton *et al.*[8] The DNA was sequenced based on Illumina Miseq whole-genome sequencing. *De novo* assembly for each DNA sample was performed using the A5-miseq pipeline, and antimicrobial resistance genes and plasmid Inc types were detected using the ABRicate program (version 0.2).

Among the 135 *E. coli* isolates, 87 were found to harbor the *bla*$_{\mathrm{CMY\text{-}2}}$ gene. In addition, the *bla*$_{\mathrm{CMY\text{-}2}}$ gene was found in the following incompatibility groups: IncI1-Iγ (n = 21, 24.1%); IncI (n = 12, 13.8%); IncB/O/K/Z (n = 28, 32.2%); IncC (n = 22, 25.3%); IncI2 (n = 2, 2.3%); IncF (n = 1, 1.1%); p0111 (n = 1, 1.1%); and untypable (n = 1, 1.1%). Numbers of the three major Inc plasmid types [IncI1 group (IncI1-Iγ and IncI), IncB/O/K/Z, and IncC] and the 3GC resistance rates for the period between 2002 and 2015 are shown in Fig. 5.2. This indicates that whereas the number of IncC plasmids remained relatively stable over this period stable, the numbers of IncI1 group and IncB/O/K/Z plasmids varied, and that the pattern of variance was correlated with the rates of 3GC resistance. This association might indicate that *bla*$_{\mathrm{CMY\text{-}2}}$-positive IncI1 group and IncB/O/K/Z plasmids play predominant roles in determining the 3GC resistance of *E. coli* isolated from healthy broilers.

Interestingly, for almost all IncI1 and IncB/O/K/Z plasmids, *bla*$_{\mathrm{CMY\text{-}2}}$ is the only antimicrobial resistance gene, whereas all IncC plasmids harbor multiple resistance genes. Accordingly, IncC plasmids may have contributed to the retention of *bla*$_{\mathrm{CMY\text{-}2}}$-positive plasmids as a consequence of selective pressures exerted by other antimicrobial agents. This would thus highlight the importance of continued prudent use of antimicrobials.

Fig. 5.2. Resistance to third-generation cephalosporins and the numbers of three types of *bla*$_{CMY-2}$-positive plasmids detected in *Escherichia coli* isolated from 2002 to 2015.



6. Current Risk Management of Antimicrobial Resistance Linked to Antimicrobial Products

Veterinary medical products (VMPs), including antimicrobial products, used for therapeutic purposes are regulated by “The Act on Securing Quality, Efficacy, and Safety of Pharmaceuticals, Medical Devices, Regenerative and Cellular Therapy Products, Gene Therapy Products, and Cosmetics (Law No.145, Series of 1960).” The purpose of this law is to regulate matters pertaining to drugs, quasi-drugs, medical devices, and regenerative and cellular therapy products to ensure their quality, efficacy, and safety at each stage of development, manufacturing (importing), marketing, retailing, and usage. In addition to VMPs, antimicrobial feed additives regulated by the Law Concerning Safety Assurance and Quality Improvement of Feed (Law No.35 of 1953) are used in the livestock industry. Compared with antimicrobial VMPs, feed additives are used at lower concentrations and for longer periods. Moreover, it is prohibited to administer antimicrobial feed additives to animals over the 7-day period preceding slaughter for human consumption.

There are specific requirements with regards to gaining marketing approval for antimicrobial VMPs in Japan. In order to obtain such approval, data relating to the antimicrobial spectrum; the results of antimicrobial susceptibility tests of recent field isolates of targeted bacteria, indicator bacteria, and zoonotic bacteria; and the results of resistance acquisition tests are submitted with the application for consideration of public and animal health issues. To gain approval of VMPs for food-producing animals, data concerning the stability of the antimicrobial substances under natural circumstances are also submitted. The antimicrobial substance in the VMP is comprehensively described in the dossier, and the period of administration is limited to 1 week, where possible.

General and specific data are evaluated at an expert meeting conducted by MAFF. The data for VMPs used in food-producing animals are also evaluated by the Food Safety Commission (FSC). The Pharmaceutical Affairs and Food Sanitation Council, which is a ministerial advisory organization, evaluates the quality, efficacy, and safety of the VMP. If the VMP satisfies all requirements, the Minister of MAFF approves the VMP. In Japan, the post-marketing surveillance of VMPs occurs at two stages: during re-examination of new VMPs and during reevaluation of all VMPs. After completion of the re-examination period for new VMPs, field investigation data relating efficacy, safety, and public and livestock health are submitted with the application. For new VMPs, the results of monitoring for antimicrobial resistance are submitted according to the requirements of the re-examination system. For all approved drugs, MAFF conducts literature reviews with respect to efficacy, safety, residues, and resistant bacteria, in accordance with the requirements of the re-evaluation system.

Given that most of the antimicrobial VMPs that have been approved as drugs require directions or prescriptions from a veterinarian, these VMPs cannot be used without the diagnosis and instruction of a veterinarian. Furthermore, the distribution and use of VMPs, including veterinary antimicrobial products, is routinely inspected by the regulatory authority (MAFF).

For the marketing and use of VMPs, veterinarians prescribe the drug and place restrictions on its use, such that the drug does not remain above maximum residue levels in livestock products. With regards to labeling, there are restrictions relating to the description on the “direct container” and on the “package insert.” The description on the label must include all of the following: (1) the prescribed drug; (2) the disease and bacterial species indicated; (3) the route, dose, and period of administration; (4) prohibition/withdrawal periods; (5) precautions for use, such as side effects and handling; and (6) in the case of specific antimicrobial drugs (fluoroquinolones, 3GCs, colistin and 15-membered macrolides), the description includes notification that the drug should not be used as a first-choice drug and should be used only when the first-choice drug has not been effective. For specific antimicrobial drugs, which are of particular importance with respect to public health, an application for approval of the drug for use in animals is not accepted until the end of the period of re-examination of the corresponding drug for use in humans. After marketing, monitoring data on the amounts sold and the appearance of antimicrobial resistance in target pathogens and food-borne pathogens must be submitted to MAFF.

The risk assessment for antimicrobial resistance in bacteria arising from the use of antimicrobials in animals, particularly in those bacteria that are commonly of concern in human medicine, is forwarded to MAFF by the FSC, which was established in 2003. The FSC is responsible for risk assessment based on the Food Safety Basic Law (Law No. 48 of 2003) and is independent of risk management organizations such as MAFF and the Ministry of Health, Labour, and Welfare (MHLW). The risk assessment for antimicrobial resistance in bacteria related to the use of antimicrobials in animals is undertaken on the basis of their guidelines, which have been established with reference to the OIE International Standards on Antimicrobial Resistance, the Codex guidelines, and Food and Drug Administration guidance (https://www.fsc.go.jp/english/standardsforriskassessment/antimicrobialresistantbacter ia_e2.data/amrglen.pdf).

To implement the risk management strategy developed based on the risk assessment undertaken by the FSC, the management guidelines for reducing the risk of antimicrobial resistance arising from antimicrobial use in food-producing animals and aquatic animals have been defined (http://www.maff.go.jp/e/policies/food_safety/attach/pdf/safevetdrug-1.pdf). The purpose of these guidelines is to mitigate the negative effects on human health attributable to antimicrobial-resistant bacteria. However, the significance of antimicrobial VMPs in veterinary medicine should be considered in order to ensure food safety and stability. The guidelines cover the entire process, from development to implementation of risk management options for on-farm animal practices, with reference to the standard guidelines for risk management adopted by MAFF and MHLW (https://www.maff.go.jp/j/syouan/seisaku/risk_analysis/sop/pdf/151001_sop.pdf).

Establishment of a risk management strategy should be undertaken by following a stepwise approach. Firstly, available and appropriate risk management options are considered based on the results of risk assessments undertaken by the FSC ("high," "medium," "low," or "negligible"), as shown in Table 6.1. In particular, the extended results of release assessments should be considered to determine risk management options. Importantly, a high-risk estimation-of-release assessment should be carefully evaluated. Secondly, to determine risk management options, the factors listed in Table 6.2 should be fully considered based on target animals and approved administration routes. Risk communication, including public comment procedures, should be implemented, as necessary. The current status of risk analysis of antimicrobial resistance in food-producing animals in Japan is shown in Table 6.3.

In addition to antimicrobial VMPs, risk assessment of antimicrobial resistance in bacteria selected by the use of antimicrobial feed additives is also conducted by FSC. For cases in which the results of risk assessments of the concerned antimicrobial feed additive indicates a "high," "medium," or "low" risk, the designation of feed additive is revoked by MAFF according to the management guidelines for antimicrobial feed additives (https://www.maff.go.jp/j/syouan/tikusui/siryo/attach/pdf/index-11.pdf; in Japanese). In other words, MAFF policy stipulates discontinuation of the use of antimicrobial feed additives in all cases apart from those for which the estimated risk to human health is deemed negligible, according to FSC risk assessment.

Under present circumstances, with the heightened risk of outbreaks due to emerging bacterial diseases, as well as viral diseases, such as foot-and-mouth disease and avian influenza, clinical veterinarians are dependent on various classes of antimicrobials to contain the spread of endemic and unexpected disease in domestic animals. Risk assessments of antimicrobial resistance in food-producing animals have been performed by the FSC. Risk management strategies for antimicrobial VMPs are established in accordance with predetermined guidelines in order to implement appropriate risk management with respect to antimicrobial resistance, taking into consideration the benefits/risks of antimicrobial use in animal husbandry.

Table 6.1. Selected examples and expected effects of risk management options for antimicrobial drugs depending on their risk assessment results

Assessment result	Examples of risk management options	Expected effects
High	Withdrawal	Distribution of the drug in the country is discontinued.
	Temporary ban on use	Distribution of the drug in the country is discontinued (temporarily).
High/ medium	Withdrawal of the antimicrobial:	
	against specific animal species	When the drug is approved for use in multiple animal species, it will be banned in some target animals. Use of the drug for the target animal should be considered for each administration route of the drug.
	against target disease/bacteria	When the drug is approved for multiple target diseases/bacterial species, it will be banned for use against some target diseases/bacteria. Use of the drug for the target animal should be considered for each target disease/bacteria.
	Limitation of antimicrobial use near the time of slaughter	Use volume of the drug is reduced by setting limits on its use during the final stage of the rearing period; otherwise, a high amount of the drug would be administered for each animal. This will prevent increases in resistant bacteria due to selective pressures during the final stage of the rearing period.

	Shortening the duration of antimicrobial administration	The course dose for each animal is reduced by shortening the dosage period of AVMPs based on veterinary diagnosis.
Medium	Strict use as secondary-line AVMPs Intensified monitoring for antimicrobial resistance	The drug is strictly used only when treatment with the first-line drug is ineffective, as stated on the label of the specific AVMPs, such as new quinolone drugs or third-generation cephalosporin antibiotics available in Japan. Changes in the resistance of bacteria are detected immediately by increasing the monitoring frequency and area.
Low/ negligible	Continued monitoring for antimicrobial resistance	-

AVMPs: antimicrobial veterinary medicinal products.

Table 6.2. Basic components required to establish criteria for risk management options

Decision factors	Comments
Significance of antimicrobial veterinary medicinal products in veterinary medicine	Severity (e.g., organs affected, potential systemic involvement, and pathology) of the target disease Significance in the clinical settings (e.g., facility, efficacy, and economy)
The availability of alternatives for the target disease	Availability of alternatives, including different classes of antimicrobials and vaccines used for the same purposes
Secondary risks	Possible harmful consequences entailed in implementing each risk-management option
Estimated efficacy of risk-management options	Extent of efficacy imposed by implementing each risk-management option
Feasibility of risk-management options	Feasibility in terms of technical, administrative, and financial issues involved in implementing each risk-management option
Other concerns	Decision factors depending on antimicrobial characteristics, whenever necessary

Table 6.3. The present status of risk assessment and risk management of antimicrobial resistance in food-producing animals in Japan (as of March 2019)

	URL of Japanese documents*	
Antimicrobials	Risk assessment	Risk management
Fluoroquinolones used for cattle and swine (2nd edition)	http://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20071024051 (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/pdf/fluoro.pdf
Tulathromycin used for swine	http://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20091124004 (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/pdf/draxxin_kanrisochi.pdf
Pirlimycin used for dairy cows	http://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20080212002 (Risk estimation: Low)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/pdf/pirlimy.pdf
Fluoroquinolones used for poultry	https://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20071024051 **https://www.jstage.jst.go.jp/article/foodsafetyfscj/2/4/2_2014035s/_article (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/pdf/risk_mana_torifq.pdf
Gamithromycin used for cattle	https://www.fsc.go.jp/fsciis/evaluationDocument/show/kya2013111337z **http://www.fsc.go.jp/english/evaluationreports/vetmedicine/July_22_2014_Gamithromycin.pdf (Risk estimation: Low)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/koukinzai-26.pdf
Ceftiofur used for cattle and swine	https://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20100201004 (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/koukinzai-12.pdf
Tulathromycin used for cattle	https://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20150310290 (Risk estimation: Low)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/koukinzai-16.pdf
Cefquinome sulfate used for cattle	http://www.fsc.go.jp/fsciis/evaluationDocument/show/kya20080115000 (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/koukinzai-17.pdf

Colistin sulfate used for livestock	http://www.fsc.go.jp/fsciis/evaluationDocument/show/kya03120816918 **http://www.fsc.go.jp/english/evaluationreports/others_e1.data/kya03120816918_202.pdf (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/torikumi-2.pdf
Gamithromycin used for swine	https://www.fsc.go.jp/fsciis/evaluationDocument/show/kya16101211801 (Risk estimation: Medium)	http://www.maff.go.jp/j/syouan/tikusui/yakuzi/attach/pdf/torikumi-1.pdf
Macrolides used for livestock	https://www.fsc.go.jp/fsciis/attachedFile/download?retrievalId=kya20031208026&fileId=201 **https://www.fsc.go.jp/fsciis/attachedFile/download?retrievalId=kya20031208026&fileId=202 (Risk estimation: Low)	Continued monitoring of antimicrobial resistance
Tetracyclines used for livestock	https://www.fsc.go.jp/fsciis/attachedFile/download?retrievalId=kya20031208030&fileId=201 **https://www.fsc.go.jp/fsciis/attachedFile/download?retrievalId=kya20031208030&fileId=202 (Risk estimation: Low)	Continued monitoring of antimicrobial resistance

* English versions are unavailable.

** Summary available in English.

7. JVARM Publications

2016

Ozawa, M., Hiki, M., Kawanishi, M., Abo, H., Kojima A., Asai, T., Hamamoto, H. 2016. Molecular typing of fluoroquinolone-resistant *Campylobacter jejuni* isolated from broilers in Japan using multilocus sequence typing and pulsed-field gel electrophoresis. *Foodborne Pathog. Dis.* 13:1–7.

Kawanishi, M., Abo, H., Ozawa, M., Uchiyama, M., Shirakawa, T., Suzuki, S., Shima, A., Yamashita, A., Sekizuka, T., Kato, K., Kuroda, M., Koike R., Kijima M. 2016. Prevalence of colistin-resistance gene *mcr-1* and absence of *mcr-2* in *Escherichia coli* isolated from healthy food producing animals in Japan. *Antimicrob. Agents Chemother.* 61(1):e02057-16.

Makita, M., Goto, M., Ozawa, M., Kawanishi, M., Koike, M., Asai, T., Tamura, Y. 2016. Multivariable analysis of the association between antimicrobial use and antimicrobial resistance in *Escherichia coli* isolated from apparently healthy pigs in Japan. *Microb. Drug Res.* 22:28–39.

Suzuki, S., Ohnishi, M., Kawanishi, M., Akiba, M., Kuroda, M. 2016. Investigation of a plasmid genome database for colistin-resistance gene *mcr-1*. *Lancet Infect. Dis*. 16:284–285.

2017

Hiki, M., Shimizu, Y., Kawanishi, M., Ozawa, M., Abo, H., Kojima, A., Koike, R., Suzuki, S., Asai, T., Hamamoto, S. 2017. Evaluation of the relationship between the minimum inhibitory concentration of ceftiofur and third-generation cephalosporins in *Escherichia coli* isolates from food-producing animals. *J. Vet. Diagn. Invest.* 29:716–772.

Ohishi, T., Aoki, K., Ishii, Y., Usui, M., Tamura, Y., Kawanishi, M., Ohnishi, K., Tateda, K. 2017. Molecular epidemiological analysis of human- and chicken-derived isolates of *Campylobacter jejuni* in Japan using next-generation sequencing. *J. Infect. Chemother.* 23:165–172.

Sekizuka, T., Kawanishi, M., Ohnishi, M., Shima, A., Kato, K., Yamashita, A., Matsui, M., Suzuki, S., Kuroda, M. 2017. Elucidation of quantitative structural diversity of remarkable rearrangement regions, shufflons, in IncI2 plasmids. *Sci. Rep.* 7:928.

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10. Materials and Methods

10.1 Sampling

(1) Monitoring System for Farms

Sampling was carried out on farms across Japan by the prefectural LHSCs. *Salmonella* and *Staphylococcus* species were isolated from diagnostic submissions of clinical cases.

(2) Monitoring System for Slaughterhouses

Sampling in slaughterhouses was carried out by private research laboratories. At each slaughterhouse, fresh fecal samples were collected from the cecum of healthy broiler chickens and from the rectum of healthy cattle and healthy pigs.

E. coli, *Enterococcus* species, and *Campylobacter* species were isolated from the cecum- and rectum-derived fecal samples obtained from healthy cattle, pigs, and broilers, whereas species of *Salmonella* were isolated from only the cecum-derived fecal samples of healthy broilers.

(3) Monitoring System for Companion Animals (Dogs and Cats)

Clinical samples submitted from animal hospitals were collected from the private clinical laboratories that had agreed to cooperate with this monitoring. To reduce selection bias, sample numbers were allocated in accordance with the numbers of companion animal hospitals and one sample for each bacterial and host species should be collected from each hospital. A contracted research laboratory informed the cooperating clinical laboratories with respect to the target bacterial species, required numbers and acceptable sampling location, and the clinical laboratories selected and sent isolates accordingly.

The target bacterial species were as follows: *E. coli* and *Klebsiella* species derived from urine and the reproductive tract, *Enterococcus* species from urine and ears, coagulase-positive *Staphylococcus* species from urine and skin, *Enterobacter* species from urine. and *Acinetobacter* species from urine and skin.

10.2 Isolation and Identification

(1) *Escherichia coli*

E. coli strains isolated from each sample were maintained on desoxycholate-hydrogen sulfate-lactose (DHL) agar (Eiken, Japan). Candidate colonies were identified biochemically using a commercially available kit (API20E; bioMérieux, Marcy l'Etoile, France) and stored at -80°C until used for testing.

(2) *Enterococcus*

Fecal samples were cultured via direct culturing using bile esculin azide agar (BEA; Difco Laboratories, Detroit, MI, USA) or using an enrichment procedure with buffered peptone water

(Oxoid, Basingstoke, Hampshire, England). In the former procedure, plates were incubated at 37°C for 48–72 h, whereas in the latter, tubes were incubated at 37°C for 18–24 h and subsequently passaged onto the same types of plates as used for the direct culturing method.

Isolates were presumptively identified as enterococci based on colony morphology. These isolates were sub-cultured onto heart infusion agar (Difco) supplemented with 5% (v/v) sheep blood, following which hemolysis was observed and Gram staining was performed. Isolates were tested for catalase production, growth in heart infusion broth supplemented with 6.5% NaCl, and growth at 45°C. In addition, the hydrolysis of L-pyrrolidonyl-β-naphthylamide and pigmentation, and cell motility were evaluated, using the API 20 STREP system (bioMérieux). When required, further identification was undertaken based on D-xylose and sucrose fermentation tests[9]. All isolates were stored at -80°C until used for testing.

(3) *Campylobacter*

Species of *Campylobacter* were isolated on *Campylobacter* blood-free selective agar (mCCDA; Oxoid, UK) using the direct inoculation method. Isolates were identified biochemically and molecularly using PCR[10]. Two isolates per sample were then selected for antimicrobial susceptibility testing and suspended in 15% glycerin, to which buffered peptone water (Oxoid) had been added, and subsequently stored at -80°C until used for testing.

(4) *Salmonella*

Salmonella isolates from farms were provided by the Livestock Hygiene Service Centers from diagnostic submissions of clinical cases, whereas samples from slaughterhouses were obtained from cecum-derived fecal samples collected from healthy broilers. The fecal samples were cultured using an enrichment procedure with buffered peptone water (Oxoid). Tubes containing the samples were incubated at 37°C for 18–24 h, followed by subsequent passaging into Rappaport–Vassiliadis broth and incubation at 42°C for a further 18–24 h. Thereafter, cultures were then passaged onto CHROMagar™ *Salmonella* plates and incubated at 37°C for 18–24 h, following which they were presumptively identified as *Salmonella* based on colony morphology.

After biochemical identification, the serotype of the isolates was determined using slide and tube agglutination tests, according to the latest versions of the Kauffmann–White scheme [11]. All isolates were stored at -80°C until used for testing.

10.3 Antimicrobial Susceptibility Testing

The MICs of *E. coli*, *Enterococcus*, *Campylobacter*, and *Salmonella* isolates were determined using the broth microdilution method according to CLSI guidelines. *Staphylococcus aureus* ATCC 29213 and *E. coli* ATCC 25922 were used as quality control strains, whereas *C. jejuni* ATCC 33560 was used for the quality control of MIC measurements in *Campylobacter* species.

10.4 Resistance Breakpoints

Resistance breakpoints were defined microbiologically in serial studies. For cases in which MICs for the isolates were bimodally distributed, values intermediate between the two peaks were defined as the breakpoints

The MIC of each antimicrobial established by CLSI was interpreted using CLSI criteria. The breakpoints of other antimicrobial agents were determined microbiologically.

10.5 Statistical Analysis

Rates of resistance determined in 2017 were compared with those determined in 2014, 2015, and 2016 in the JVARM program using the chi-square test followed by Ryan's multiple comparison method[12)]. For cases in which the expected frequency was less than 5, Fisher's exact test was used. Differences were considered significant at $p < 0.05$.

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Table 12.1.1. Distribution of MICs and resistance(%) in *Escherichia coli* from cattle(n=258), pigs(n=90) and broilers(n=158) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	4.0	8.0	7.4	4.49-11.27						2.3	12.0	41.9	36.4				1.2	6.2	
	Pigs	8.0	>128	36.7	26.75-47.49							10.0	22.2	30.0	1.1			1.1	35.6	
	Broilers	8.0	>128	36.1	28.59-44.09							10.1	29.7	23.4	0.6			1.9	34.2	
	Total	8.0	>128	21.5	18.03-25.39						1.2	11.1	34.6	31.2	0.4			1.4	20.2	
Cefazolin	Cattle	≦1	2.0	1.2	0.24-3.37						65.5	29.8	2.7	0.8				0.4	0.8	
	Pigs	2.0	4.0	1.1	0.02-6.04						23.3	57.8	12.2	5.6		1.1				
	Broilers	2.0	8.0	7.0	3.52-12.12						38.6	43.0	7.6	3.2	0.6	1.3	0.6		5.1	
	Total	2.0	4.0	3.0	1.66-4.85						49.6	38.9	5.9	2.4	0.2	0.6	0.2	0.2	2.0	
Cefotaxime	Cattle	0.12	0.12	0.4	0.00-2.15			96.9	1.6		0.4	0.8				0.4				
	Pigs	0.12	0.12	1.1	0.02-6.04			97.8			1.1					1.1				
	Broilers	0.12	0.25	5.7	2.63-10.54			88.6	4.4		0.6	0.6		1.9	1.3	2.5				
	Total	0.12	0.1	2.2	1.09-3.86			94.5	2.2		0.6	0.6		0.6	0.4	1.2				
Streptomycin	Cattle	8.0	>64	22.1	17.18-27.66							0.8	33.7	38.8	4.7	1.9	5.0	7.0	8.1	
	Pigs	16.0	>64	50.0	39.26-60.74								4.4	27.8	17.8	10.0	5.6	5.6	28.9	
	Broilers	32.0	>64	51.3	43.19-59.29							5.1	15.8	17.7	10.1	7.0	11.4	7.0	25.9	
	Total	8.0	>64	36.2	31.97-40.53							2.0	22.9	30.2	8.7	4.9	7.1	6.7	17.4	
Gentamicin	Cattle	≦0.5	1.0	0.8	0.09-2.78					76.0	17.8	4.7	0.8		0.4	0.4				
	Pigs	1.0	4.0	3.3	0.69-9.44					34.4	27.8	24.4	10.0		2.2		1.1			
	Broilers	≦0.5	4.0	5.1	2.21-9.74					53.2	24.7	10.8	4.4	1.9	1.9	1.3	1.3	0.6		
	Total	≦0.5	2.0	2.6	1.37-4.36					61.5	21.7	10.1	3.6	0.6	1.2	0.6	0.6	0.2		
Kanamycin	Cattle	4.0	8.0	4.3	2.14-7.51						1.6	45.3	35.3	12.0	1.6			0.4	3.9	
	Pigs	4.0	16.0	10.0	4.67-18.14						2.2	11.1	36.7	27.8	12.2			1.1	8.9	
	Broilers	16.0	>128	43.7	35.80-51.78						5.7	14.6	12.0	15.8	7.6	0.6	1.3	2.5	39.9	
	Total	4.0	>128	17.6	14.37-21.20						3.0	29.6	28.3	16.0	5.3	0.2	0.4	1.2	16.0	

Table 12.1.1. Distribution of MICs and resistance(%) in *Escherichia coli* from cattle(n=258), pigs(n=90) and broilers(n=158) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Tetracycline	Cattle	4.0	>64	29.8	24.32-35.84					0.4	9.7	19.0	38.0	3.1	3.1	1.6	9.3	15.9		
	Pigs	64.0	>64	56.7	45.80-67.09						6.7	11.1	17.8	7.8		2.2	15.6	38.9		
	Broilers	64.0	>64	56.3	48.22-64.20						5.7	21.5	12.0	4.4	0.6	1.9	22.2	31.6		
	Total	4.0	>64	42.9	38.52-47.33					0.2	7.9	18.4	26.3	4.3	1.8	1.8	14.4	24.9		
Nalidixic acid	Cattle	4.0	4.0	2.3	0.85-5.00						0.4	20.2	69.8	7.4		0.4		0.8	1.2	
	Pigs	4.0	>128	15.6	8.77-24.73							11.1	52.2	16.7	4.4	1.1	1.1		13.3	
	Broilers	4.0	>128	35.4	28.00-43.44							11.4	46.2	6.3	0.6	1.3	0.6	5.1	28.5	
	Total	4.0	>128	15.0	12.02-18.44						0.2	15.8	59.3	8.7	1.0	0.8	0.4	2.0	11.9	
Ciprofloxacin	Cattle	≦0.03	≦0.03	0.4	0.00-2.15	95.0	1.9	0.8	0.4	0.8	0.8		0.4							
	Pigs	≦0.03	0.25	4.4	1.22-11.00	74.4		5.6	12.2	1.1	2.2			4.4						
	Broilers	≦0.03	4.0	10.1	5.89-15.93	60.8	2.5	8.2	12.7	2.5	1.3	1.9	3.8	6.3						
	Total	≦0.03	0.25	4.2	2.58-6.28	80.6	1.8	4.0	6.3	1.4	1.2	0.6	1.4	2.8						
Colistin	Cattle	0.25	0.5	0.4	0.00-2.15			28.3	45.7	22.5	1.9	1.2				0.4				
	Pigs	0.5	1.0	1.1	0.02-6.04			7.8	32.2	45.6	10.0		3.3			1.1				
	Broilers	0.25	0.5	1.9	0.39-5.45			28.5	44.9	18.4	5.1	0.6	0.6			1.9				
	Total	0.25	0.5	1.0	0.32-2.30			24.7	43.1	25.3	4.3	0.8	0.8			1.0				
Chloramphenicol	Cattle	8.0	16.0	2.3	0.85-5.00							0.4	13.2	76.0	8.1				2.3	
	Pigs	8.0	>128	25.6	16.94-35.84							2.2	7.8	51.1	13.3	1.1	5.6	6.7	12.2	
	Broilers	8.0	>128	19.6	13.73-26.68								17.7	53.8	8.9	1.9	3.2	3.2	11.4	
	Total	8.0	64.0	11.9	9.17-15.00							0.6	13.6	64.6	9.3	0.8	2.0	2.2	6.9	

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs							
						2.38/0.12	4.75/0.25	9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	Cattle	≦0.12	1.0	5.4	2.99-8.94	67.4	12.0	10.1	4.7	0.4	0.4	0.4	4.7
	Pigs	0.5	>8	28.9	19.81-39.40	34.4	13.3	5.6	12.2	5.6	1.1		27.8
	Broilers	0.5	>8	28.5	21.59-36.20	37.3	9.5	12.7	10.1	1.9	1.3		27.2
	Total	≦0.12	>8	16.8	13.64-20.35	52.2	11.5	10.1	7.7	1.8	0.8	0.2	15.8

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.1.2. Distribution of MICs and resistance(%) in *Escherichia coli* from cattle(n=252), pigs(n=83) and broilers(n=150) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC$_{50}$	MIC$_{90}$	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	4.0	8.0	4.8	2.48-8.18						4.0	19.4	64.3	7.5					4.8	
	Pigs	4.0	>128	33.7	23.71-44.95						1.2	26.5	36.1	2.4			1.2		32.5	
	Broilers	4.0	>128	39.3	31.46-47.64						1.3	10.7	40.7	7.3	0.7	0.7			38.7	
	Total	4.0	>128	20.4	16.91-24.28						2.7	17.9	52.2	6.6	0.2	0.2	0.2		20.0	
Cefazolin	Cattle	≦1	2.0	0.8	0.09-2.84						79.8	18.3	1.2					0.4	0.4	
	Pigs	≦1	4.0	1.2	0.03-6.54						53.0	36.1	9.6						1.2	
	Broilers	≦1	4.0	4.7	1.89-9.38						56.0	31.3	6.0	1.3	0.7				4.7	
	Total	≦1	2.0	2.1	0.99-3.76						67.8	25.4	4.1	0.4	0.2			0.2	1.9	
Cefotaxime	Cattle	0.12	0.12	0.4	0.01-2.20			98.0	0.4		1.2			0.4						
	Pigs	0.12	0.12	1.2	0.03-6.54			98.8							1.2					
	Broilers	0.12	0.12	4.7	1.89-9.38			94.7	0.7					2.0	1.3	1.3				
	Total	0.12	0.12	1.9	0.85-3.50			97.1	0.4		0.6			0.8	0.6	0.4				
Streptomycin	Cattle	4.0	64.0	19.0	14.39-24.45							0.8	53.6	23.4	3.2	3.2	6.7	3.6	5.6	
	Pigs	16.0	>64	41.0	30.28-52.31								19.3	27.7	12.0	6.0	9.6	3.6	21.7	
	Broilers	8.0	>64	41.3	33.36-49.66								19.3	34.7	4.7	4.0	6.0	5.3	26.0	
	Total	8.0	>64	29.7	25.65-33.98							0.4	37.1	27.6	5.2	3.9	7.0	4.1	14.6	
Gentamicin	Cattle	≦0.5	≦0.5	0.0	0.00-1.46					90.5	8.7	0.8								
	Pigs	≦0.5	1.0	3.6	0.75-10.21					73.5	20.5	2.4				2.4		1.2		
	Broilers	≦0.5	1.0	6.0	2.77-11.09					72.7	18.7	2.0		0.7	4.0	1.3	0.7			
	Total	≦0.5	1.0	2.5	1.28-4.29					82.1	13.8	1.4		0.2	1.2	0.8	0.2	0.2		
Kanamycin	Cattle	2.0	4.0	1.2	0.24-3.44						7.1	73.8	15.5	2.4					1.2	
	Pigs	2.0	128.0	10.8	5.07-19.59						4.8	47.0	32.5	4.8				2.4	8.4	
	Broilers	4.0	>128	36.7	28.95-44.92						4.0	33.3	20.7	4.0	1.3		2.0		34.7	
	Total	2.0	>128	13.8	10.86-17.21						5.8	56.7	20.0	3.3	0.4		0.6	0.4	12.8	

Table 12.1.2. Distribution of MICs and resistance(%) in *Escherichia coli* from cattle(n=252), pigs(n=83) and broilers(n=150) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Tetracycline	Cattle	2.0	64.0	21.0	16.16-26.59					0.8	24.6	49.6	2.8	1.2	1.2	1.2	10.7	7.9		
	Pigs	32.0	>64	55.4	44.10-66.35						13.3	28.9	1.2	1.2		6.0	26.5	22.9		
	Broilers	2.0	>64	46.0	37.84-54.32						12.7	38.7	2.0	0.7	0.7	4.7	24.0	16.7		
	Total	2.0	>64	34.6	30.40-39.07					0.4	19.0	42.7	2.3	1.0	0.8	3.1	17.5	13.2		
Nalidixic acid	Cattle	4.0	4.0	2.0	0.64-4.57						0.8	42.5	53.2	1.2	0.4				2.0	
	Pigs	4.0	128.0	12.0	5.93-21.05							41.0	33.7	9.6	3.6			8.4	3.6	
	Broilers	4.0	>128	39.3	31.46-47.64						0.7	27.3	30.7	0.7	1.3	0.7	0.7	6.0	32.0	
	Total	4.0	>128	15.3	12.17-18.78						0.6	37.5	42.9	2.5	1.2	0.2	0.2	3.3	11.5	
Ciprofloxacin	Cattle	≦0.03	≦0.03	0.0	0.00-1.46	98.0	0.8		0.4	0.8										
	Pigs	≦0.03	≦0.03	0.0	0.00-4.35	97.6			1.2	1.2										
	Broilers	≦0.03	4.0	12.0	7.26-18.31	58.7	1.3	4.7	13.3	5.3	4.0	0.7	3.3	8.7						
	Total	≦0.03	0.25	3.7	2.21-5.81	85.8	0.8	1.4	4.5	2.3	1.2	0.2	1.0	2.7						
Colistin	Cattle	≦0.12	0.25	1.2	0.09-2.84			55.6	42.9	0.4			0.4			0.8				
	Pigs	≦0.12	0.25	2.4	0.00-4.35			71.1	22.9	2.4		1.2	2.4							
	Broilers	0.25	0.25	3.3	0.00-2.43			33.3	58.0	4.0		1.3	3.3							
	Total	≦0.12	0.25	2.1	0.04-1.49			51.3	44.1	1.9		0.6	1.6			0.4				
Chloramphenicol	Cattle	8.0	8.0	2.8	1.12-5.64							0.8	38.5	56.3	1.6			1.2	1.6	
	Pigs	8.0	>128	21.7	13.38-32.10							1.2	14.5	61.4	1.2		3.6	7.2	10.8	
	Broilers	8.0	64.0	11.3	6.74-17.53							2.0	24.0	58.0	4.7		2.7	1.3	7.3	
	Total	8.0	16.0	8.7	6.31-11.53							1.2	29.9	57.7	2.5		1.4	2.3	4.9	

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs							
						2.38/0.12	4.75/0.25	9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	Cattle	≦0.12	0.25	2.0	0.64-4.57	86.5	6.3	4.8	0.4				2.0
	Pigs	≦0.12	>8	26.5	17.41-37.34	54.2	10.8	6.0		2.4			26.5
	Broilers	≦0.12	>8	34.7	27.09-42.87	56.0	6.0	2.0	0.7	0.7			34.7
	Total	≦0.12	>8	16.3	13.11-19.89	71.5	7.0	4.1	0.4	0.6			16.3

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.2.1. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from cattle(n=8), pigs(n=23) and broilers(n=96) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	Cattle	0.5	1.0	0.0	0.00 -36.95				50.0	50										
	Pigs	1.0	1.0	0.0	0.00 -14.82			4.3	39.1	56.5										
	Broilers	1.0	1.0	0.0	0.00 -3.77		1.0		34.4	63.5	1.0									
	Total	1.0	1.0	0.0	0.00 -2.87		0.8	0.8	36.2	61.4	0.8									
Dihydrostreptomycin	Cattle	16.0	128.0	12.5	0.31 -52.66								12.5	37.5	37.5		12.5			
	Pigs	64.0	512.0	43.5	23.19 -65.51								4.3	17.4	13.0	21.7	8.7	4.3	8.7	21.7
	Broilers	64.0	512.0	40.6	30.71 -51.14								1.0	8.3	37.5	12.5	3.1	8.3	8.3	20.8
	Total	64.0	512.0	39.4	30.82 -48.43								2.4	11.8	33.1	13.4	4.7	7.1	7.9	19.7
Gentamicin	Cattle	2.0	8.0	0.0	0.00 -36.95					25.0	25.0	25.0	25.0							
	Pigs	4.0	16.0	8.7	1.07 -28.04					13.0	21.7	34.8	8.7	13.0	4.3		4.3			
	Broilers	4.0	8.0	6.3	2.32 -13.11					2.1	12.5	36.5	39.6	3.1	2.1	1.0		1.0	2.1	
	Total	4.0	16.0	6.3	2.75 -12.04					5.5	15.0	35.4	33.1	4.7	2.4	0.8	0.8	0.8	1.6	
Kanamycin	Cattle	8.0	64.0	0.0	0.00 -36.95							12.5	37.5	12.5	25.0	12.5				
	Pigs	32.0	512.0	30.4	13.21 -52.92								13.0	8.7	30.4	17.4			4.3	26.1
	Broilers	512.0	512.0	55.2	44.71 -65.38							1.0	5.2	8.3	13.5	16.7	3.1	1.0		51.0
	Total	64.0	512.0	47.2	38.32 -56.30							1.6	8.7	8.7	17.3	16.5	2.4	0.8	0.8	43.3
Oxytetracycline	Cattle	1.0	32.0	37.5	8.52 -75.52			12.5	12.5	37.5					37.5					
	Pigs	64.0	>64	73.9	51.59 -89.78				8.7	17.4					17.4	8.7	47.8			
	Broilers	>64	>64	83.3	74.25 -90.25			1.0	5.2	4.2	1.0	1.0	4.2	4.2	19.8	3.1	56.3			
	Total	>64	>64	78.7	70.54 -85.55			1.6	6.3	8.7	0.8	0.8	3.1	3.1	20.5	3.9	51.2			
Chloramphenicol	Cattle	8.0	32.0	12.5	0.31 -52.66						12.5	12.5	62.5		12.5					
	Pigs	8.0	128.0	39.1	19.70 -61.46							4.3	47.8	8.7	4.3	4.3	30.4			
	Broilers	8.0	64.0	15.6	9.01 -24.46							3.1	60.4	20.8	2.1	7.3	6.3			
	Total	8.0	128.0	19.7	13.16 -27.68						0.8	3.9	58.3	17.3	3.1	6.3	10.2			
Bacitracin	Cattle	128.0	256.0	-	-											12.5	50.0	37.5		
	Pigs	128.0	256.0	-	-								8.7				43.5	43.5		4.3
	Broilers	256.0	512.0	-	-								1.0	1.0	2.1	5.2	25.0	41.7	2.1	21.9
	Total	256.0	512.0	-	-								2.4	0.8	1.6	4.7	29.9	41.7	1.6	17.3

Table 12.2.1. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from cattle(n=8), pigs(n=23) and broilers(n=96) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Virginiamycin	Cattle	4.0	8.0	-	-							87.5	12.5							
	Pigs	8.0	8.0	-	-					4.3	13.0	26.1	56.5							
	Broilers	8.0	8.0	-	-				1.0	2.1	3.1	36.5	47.9	7.3	2.1					
	Total	8.0	8.0	-	-				0.8	2.4	4.7	37.8	47.2	5.5	1.6					
Erythromycin	Cattle	1.0	2.0	0.0	0.00 -36.95		12.5			37.5	50.0									
	Pigs	16.0	>128	52.2	30.58 -73.19		13.0	4.3	4.3		26.1			4.3				47.8		
	Broilers	>128	>128	59.4	48.86 -69.29		3.1	1.0	16.7	2.1	13.5	4.2		1.0		1.0		57.3		
	Total	>128	>128	54.3	45.24 -63.22		5.5	1.6	13.4	3.9	18.1	3.1		1.6		0.8		52.0		
Tylosin	Cattle	2.0	2.0	0.0	0.00 -36.95					25.0	75.0									
	Pigs	>256	>256	52.2	30.58 -73.19						34.8	8.7			4.3				52.2	
	Broilers	>256	>256	59.4	48.86 -69.29						26.0	14.6							59.4	
	Total	>256	>256	54.3	45.24 -63.22					1.6	30.7	12.6			0.8				54.3	
Lincomycin	Cattle	16.0	32.0	0.0	0.00 -36.95								25.0	25.0	50.0					
	Pigs	>256	>256	56.5	34.49 -76.81									8.7	30.4	4.3			56.5	
	Broilers	>256	>256	59.4	48.86 -69.29								1.0	5.2	27.1	7.3	2.1		57.3	
	Total	>256	>256	55.1	46.04 -63.95								2.4	7.1	29.1	6.3	1.6		53.5	
Enrofloxacin	Cattle	0.5	1.0	0.0	0.00 -36.95			12.5	50.0	37.5										
	Pigs	0.5	1.0	0.0	0.00 -14.82			13.0	52.2	34.8										
	Broilers	0.5	1.0	2.1	0.25 -7.33			5.2	58.3	34.4		2.1								
	Total	0.5	1.0	1.6	0.19 -5.58			7.1	56.7	34.6		1.6								
Salinomycin	Cattle	1.0	1.0	-	-				12.5	87.5										
	Pigs	1.0	2.0	-	-					52.2	47.8									
	Broilers	2.0	8.0	-	-				4.2	42.7	28.1	8.3	13.5	3.1						
	Total	1.0	8.0	-	-				3.9	47.2	29.9	6.3	10.2	2.4						
Vancomycin	Cattle	1.0	2.0	0.0	0.00-36.95				12.5	75.0	12.5									
	Pigs	1.0	2.0	0.0	0.00-14.82				8.7	60.9	30.4									
	Broilers	1.0	2.0	0.0	0.00-3.77				5.2	61.5	33.3									
	Total	1.0	2.0	0.0	0.00-2.87				6.3	62.2	31.5									

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.2.2. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from cattle(n=10), pigs(n=13) and broilers(n=85) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	Cattle	1.0	1.0	0.0	0.00 -30.85				20.0	80										
	Pigs	1.0	1.0	0.0	0.00 -24.71			15.4	23.1	61.5										
	Broilers	1.0	1.0	0.0	0.00-4.25			1.2	42.4	54.1		2.4								
	Total	1.0	1.0	0.0	0.00-3.36			2.8	38.0	57.4		1.9								
Dihydrostreptomycin	Cattle	64.0	64.0	0.0	0.00 -30.85									10.0		90.0				
	Pigs	64.0	512.0	38.5	13.85 -68.43									7.7	15.4	38.5	7.7			30.8
	Broilers	64.0	512.0	38.8	28.43-50.02									1.2	32.9	27.1	1.2	1.2	24.7	11.8
	Total	64.0	512.0	35.2	26.24-44.97									2.8	27.8	34.3	1.9	0.9	19.4	13.0
Gentamicin	Cattle	8.0	8.0	0.0	0.00 -30.85						10.0		80.0	10.0						
	Pigs	8.0	16.0	7.7	0.19 -36.03					7.7		15.4	46.2	23.1		7.7				
	Broilers	8.0	8.0	3.5	0.73-9.97						3.5	20.0	68.2	4.7					3.5	
	Total	8.0	16.0	3.7	1.01-9.22					0.9	3.7	17.6	66.7	7.4		0.9			2.8	
Kanamycin	Cattle	32.0	64.0	0.0	0.00 -30.85								10.0		70.0	20.0				
	Pigs	64.0	512.0	30.8	9.09 -61.43								15.4	7.7	23.1	23.1				30.8
	Broilers	512.0	512.0	58.8	47.62-69.40								1.2		31.8	8.2				58.8
	Total	64.0	512.0	50.0	40.22-59.78								3.7	0.9	34.3	11.1				50.0
Oxytetracycline	Cattle	0.5	0.5	10.0	0.25 -44.51			10.0	80.0								10.0			
	Pigs	>64	>64	84.6	54.55 -98.08				15.4					7.7	23.1		53.8			
	Broilers	>64	>64	65.9	54.79-75.83			1.2	17.6			1.2	14.1	7.1	7.1	2.4	49.4			
	Total	32.0	>64	63.0	53.13-72.06			1.9	23.1			0.9	11.1	6.5	8.3	1.9	46.3			
Chloramphenicol	Cattle	4.0	4.0	10.0	0.25 -44.51						10.0	80.0					10.0			
	Pigs	8.0	128.0	38.5	13.85 -68.43							38.5	23.1		15.4		23.1			
	Broilers	4.0	64.0	12.9	6.64-21.98						2.4	64.7	18.8	1.2	1.2	9.4	2.4			
	Total	4.0	64.0	15.7	9.44-24.01						2.8	63.0	17.6	0.9	2.8	7.4	5.6			
Bacitracin	Cattle	128.0	256.0	-	-										10.0	10.0	30.0	50.0		
	Pigs	256.0	256.0	-	-											7.7	38.5	53.8		
	Broilers	128.0	512.0	-	-										1.2	12.9	43.5	29.4	2.4	10.6
	Total	128.0	512.0	-	-										1.9	12.0	41.7	34.3	1.9	8.3

Table 12.2.2. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from cattle(n=10), pigs(n=13) and broilers(n=85) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Virginiamycin	Cattle	8.0	8.0	-	-						10.0	20.0	70.0							
	Pigs	8.0	16.0	-	-						15.4		61.5	23.1						
	Broilers	8.0	8.0	-	-						1.2	15.3	80.0	3.5						
	Total	8.0	8.0	-	-						3.7	13.9	76.9	5.6						
Azithromycin	Cattle	8.0	>64	-	-				20.0			20.0	20.0	20.0			20.0			
	Pigs	8.0	>64	-	-				7.7	7.7		23.1	23.1		15.4		23.1			
	Broilers	>64	>64	-	-			1.2		1.2	2.4	9.4	21.2	12.9	1.2		50.6			
	Total	16.0	>64	-	-			0.9	2.8	1.9	1.9	12.0	21.3	12.0	2.8		44.4			
Erythromycin	Cattle	2.0	4.0	10.0	0.25 -44.51		10.0		10.0	20.0	30.0	20.0						10.0		
	Pigs	>128	>128	61.5	31.57 -86.15		23.1				15.4							61.5		
	Broilers	16.0	>128	58.8	47.62-69.40			1.2	4.7	8.2	15.3	11.8	3.5	5.9	5.9	7.1	5.9	30.6		
	Total	16.0	>128	54.6	44.76-64.24		3.7	0.9	4.6	8.3	16.7	11.1	2.8	4.6	4.6	5.6	4.6	32.4		
Tylosin	Cattle	2.0	8.0	10.0	0.25 -44.51						70.0	10.0	10.0						10.0	
	Pigs	>256	>256	61.5	31.57 -86.15						23.1	15.4							61.5	
	Broilers	>256	>256	60.0	48.80-70.49					2.4	37.6							2.4	57.6	
	Total	>256	>256	55.6	45.68-65.12					1.9	38.9	2.8	0.9					1.9	53.7	
Lincomycin	Cattle	32.0	64.0	10.0	0.25 -44.51									10.0	70.0	10.0	10.0			
	Pigs	>256	>256	61.5	31.57 -86.15										38.5				61.5	
	Broilers	256.0	>256	55.3	44.11-66.10								1.2	14.1	24.7	4.7	3.5	2.4	49.4	
	Total	128.0	>256	51.9	42.03-61.57								0.9	12.0	30.6	4.6	3.7	1.9	46.3	
Enrofloxacin	Cattle	0.5	1.0	0.0	0.00 -30.85			10.0	70.0	20.0										
	Pigs	0.5	0.5	0.0	0.00 -24.71				100.0											
	Broilers	0.5	0.5	0.0	0.00-4.25			16.5	75.3	5.9	2.4									
	Total	0.5	0.5	0.0	0.00-3.36			13.9	77.8	6.5	1.9									
Salinomycin	Cattle	2.0	2.0	-	-					20.0	80.0									
	Pigs	2.0	2.0	-	-					7.7	92.3									
	Broilers	2.0	8.0	-	-				1.2	40.0	9.4	32.9	15.3	1.2						
	Total	2.0	8.0	-	-				0.9	34.3	25.9	25.9	12.0	0.9						
Vancomycin	Cattle	1.0	2.0	0.0	0.00-30.85				10.0	60.0	30.0									
	Pigs	1.0	2.0	0.0	0.00-24.71			7.7	7.7	46.2	38.5									
	Broilers	1.0	2.0	0.0	0.00-4.25				5.9	57.6	36.5									
	Total	1.0	2.0	0.0	0.00-3.36			0.9	6.5	56.5	36.1									

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.3.1. Distribution of MICs and resistance(%) in *Enterococcus faecium* from cattle(n=4), pigs(n=7) and broilers(n=10) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	Cattle	1.0	2.0	0.0	0.00-60.24				25.0	50.0	25.0									
	Pigs	1.0	4.0	0.0	0.00-40.97				14.3	57.1	14.3	14.3								
	Broilers	1.0	2.0	0.0	0.00-30.85				10.0	70.0	10.0		10.0							
	Total	1.0	2.0	0.0	0.00-16.11				14.3	61.9	14.3	4.8	4.8							
Dihydrostreptomycin	Cattle	32.0	128.0	25.0	0.63-80.59									25.0	50.0		25.0			
	Pigs	64.0	512.0	28.6	3.66-70.96									28.6	14.3	28.6			28.6	
	Broilers	32.0	512.0	30.0	6.67-65.25									20.0	40.0	10.0		10.0	10.0	10.0
	Total	32.0	512.0	28.6	11.28-52.18									23.8	33.3	14.3	4.8	4.8	14.3	4.8
Gentamicin	Cattle	2.0	8.0	0.0	0.00-60.24						50.0	25.0	25.0							
	Pigs	4.0	8.0	0.0	0.00-40.97					14.3	28.6	42.9	14.3							
	Broilers	4.0	8.0	10.0	0.25-44.51						40.0	40.0	10.0						10.0	
	Total	4.0	8.0	4.8	0.12-23.82					4.8	38.1	38.1	14.3						4.8	
Kanamycin	Cattle	32.0	64.0	0.0	0.00-60.24									25.0	25.0	50.0				
	Pigs	64.0	512.0	28.6	3.66-70.96									28.6		42.9		14.3		14.3
	Broilers	64.0	512.0	40.0	12.15-73.77									20.0		40.0	20.0			20.0
	Total	64.0	512.0	28.6	11.28-52.18									23.8	4.8	42.9	9.5	4.8		14.3
Oxytetracycline	Cattle	0.5	1.0	0.0	0.00-60.24			25.0	50.0	25.0										
	Pigs	0.5	>64	42.9	9.89-81.6		14.3		42.9						14.3		28.6			
	Broilers	16.0	>64	60.0	26.23-87.85				30.0	10.0				10.0		10.0	40.0			
	Total	1.0	>64	42.9	21.81-65.98		4.8	4.8	38.1	9.5				4.8	4.8	4.8	28.6			
Chloramphenicol	Cattle	4.0	8.0	0.0	0.00-60.24							50.0	50.0							
	Pigs	8.0	8.0	0.0	0.00-40.97						14.3		85.7							
	Broilers	8.0	8.0	0.0	0.00-30.85							40.0	50.0	10.0						
	Total	8.0	8.0	0.0	0.00-16.11						4.8	28.6	61.9	4.8						
Bacitracin	Cattle	128.0	512.0	-	-											25.0	25.0	25.0		25.0
	Pigs	128.0	512.0	-	-								14.3			14.3	42.9	14.3		14.3
	Broilers	256.0	512.0	-	-										10.0			60.0		30.0
	Total	256.0	512.0	-	-								4.8		4.8	9.5	19.0	38.1		23.8

Table 12.3.1. Distribution of MICs and resistance(%) in *Enterococcus faecium* from cattle(n=4), pigs(n=7) and broilers(n=10) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Virginiamycin	Cattle	2.0	2.0	-	-		25.0				75.0									
	Pigs	1.0	2.0	-	-			14.3	14.3	42.9	28.6									
	Broilers	1.0	2.0	-	-				30.0	40.0	20.0		10.0							
	Total	1.0	2.0	-	-		4.8	4.8	19.0	33.3	33.3		4.8							
Erythromycin	Cattle	2.0	8.0	25.0	0.63-80.59					25.0	25.0	25.0	25.0							
	Pigs	8.0	>128	57.1	18.40-90.11						14.3	28.6	28.6			14.3		14.3		
	Broilers	1.0	>128	20.0	2.52-55.61		20.0	20.0		20.0	10.0	10.0						20.0		
	Total	4.0	>128	33.3	14.58-56.97		9.5	9.5		14.3	14.3	19.0	14.3			4.8		14.3		
Tylosin	Cattle	4.0	8.0	0.0	0.00-60.24						25.0	50.0	25.0							
	Pigs	8.0	>256	28.6	3.66-70.96						28.6	14.3	28.6						28.6	
	Broilers	4.0	256.0	20.0	2.52-55.61						20.0	30.0	30.0					10.0	10.0	
	Total	4.0	>256	19.0	5.44-41.91						23.8	28.6	28.6					4.8	14.3	
Lincomycin	Cattle	8.0	16.0	0.0	0.00-60.24				25.0				25.0	50.0						
	Pigs	32.0	>256	28.6	3.66-70.96				14.3			14.3		14.3	28.6				28.6	
	Broilers	32.0	>256	20.0	2.52-55.61				10.0					20.0	50.0				20.0	
	Total	32.0	>256	19.0	5.44-41.91				14.3			4.8	4.8	23.8	33.3				19.0	
Enrofloxacin	Cattle	1.0	8.0	25.0	0.63-80.59				25.0	50.0			25.0							
	Pigs	0.5	2.0	0.0	0.00-40.97			14.3	42.9	28.6	14.3									
	Broilers	1.0	4.0	30.0	6.67-65.25			10.0	30.0	20.0	10.0	20.0	10.0							
	Total	1.0	4.0	19.0	5.44-41.91			9.5	33.3	28.6	9.5	9.5	9.5							
Salinomycin	Cattle	2.0	4.0	-	-						75.0	25.0								
	Pigs	2.0	2.0	-	-					14.3	85.7									
	Broilers	2.0	4.0	-	-					20.0	30.0	40.0	10.0							
	Total	2.0	4.0	-	-					14.3	57.1	23.8	4.8							
Vancomycin	Cattle	0.5	4.0	0.0	0.00-60.24				50.0	25.0		25.0								
	Pigs	0.5	2.0	0.0	0.00-40.97			14.3	57.1	14.3	14.3									
	Broilers	0.5	0.5	0.0	0.00-30.85			20.0	70.0		10.0									
	Total	0.5	2.0	0.0	0.00-16.11			14.3	61.9	9.5	9.5	4.8								

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.3.2. Distribution of MICs and resistance(%) in *Enterococcus faecium* from cattle(n=4), pigs(n=11) and broilers(n=22) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	Cattle	1.0	1.0	0.0	0.00-60.24			25.0		75.0										
	Pigs	1.0	2.0	0.0	0.00-28.50				18.2	54.5	18.2		9.1							
	Broilers	1.0	1.0	0.0	0.00-15.44		4.5	9.1	18.2	63.6		4.5								
	Total	1.0	2.0	0.0	0.00-9.49		2.7	8.1	16.2	62.2	5.4	2.7	2.7							
Dihydrostreptomycin	Cattle	32.0	64.0	0.0	0.00-60.24										75.0	25.0				
	Pigs	64.0	512.0	27.3	6.02-60.98										27.3	45.5				27.3
	Broilers	32.0	512.0	18.2	5.18-40.29								4.5		59.1	18.2	4.5		13.6	
	Total	32.0	512.0	18.9	7.95-35.21								2.7		51.4	27.0	2.7		8.1	8.1
Gentamicin	Cattle	4.0	8.0	0.0	0.00-60.24						25.0	50.0	25.0							
	Pigs	8.0	8.0	0.0	0.00-28.50						9.1	27.3	63.6							
	Broilers	4.0	8.0	9.1	1.12-29.17					4.5		54.5	31.8					4.5	4.5	
	Total	4.0	8.0	5.4	0.66-18.20					2.7	5.4	45.9	40.5					2.7	2.7	
Kanamycin	Cattle	64.0	128.0	50.0	6.75-93.25										25.0	25.0	50.0			
	Pigs	128.0	512.0	72.7	39.02-93.98									9.1	9.1	9.1	36.4	18.2		18.2
	Broilers	64.0	512.0	45.5	24.38-67.79									4.5	18.2	31.8	18.2			27.3
	Total	128.0	512.0	54.1	36.92-70.52									5.4	16.2	24.3	27.0	5.4		21.6
Oxytetracycline	Cattle	0.3	0.3	0.0	0.00-60.24			100												
	Pigs	16.0	>64	54.5	23.37-83.26			27.3	18.2					9.1	9.1		36.4			
	Broilers	0.3	>64	31.8	13.86-54.88			59.1	4.5				4.5		4.5	4.5	22.7			
	Total	0.3	>64	35.1	20.20-52.54			54.1	8.1				2.7	2.7	5.4	2.7	24.3			
Chloramphenicol	Cattle	4.0	4.0	0.0	0.00-60.24						25.0	75.0								
	Pigs	4.0	4.0	9.1	0.22-41.28							90.9			9.1					
	Broilers	2.0	4.0	9.1	1.12-29.17						50.0	40.9			4.5	4.5				
	Total	4.0	4.0	8.1	1.70-21.91						32.4	59.5			5.4	2.7				
Bacitracin	Cattle	256.0	512.0	-	-												25.0	50.0		25.0
	Pigs	256.0	512.0	-	-										9.1	9.1	18.2	18.2	36.4	9.1
	Broilers	256.0	512.0	-	-									4.5			31.8	31.8	13.6	18.2
	Total	256.0	512.0	-	-									2.7	2.7	2.7	27.0	29.7	18.9	16.2

Table 12.3.2. Distribution of MICs and resistance(%) in *Enterococcus faecium* from cattle(n=4), pigs(n=11) and broilers(n=22) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs 0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Virginiamycin	Cattle	0.5	2.0	-	-				50.0		50.0									
	Pigs	2.0	2.0	-	-				27.3		63.6	9.1								
	Broilers	2.0	8.0	-	-			9.1	4.5	18.2	40.9	13.6	13.6							
	Total	2.0	4.0	-	-			5.4	16.2	10.8	48.6	10.8	8.1							
Azithromycin	Cattle	4.0	16.0	-	-							50.0	25.0	25.0						
	Pigs	8.0	>64	-	-				18.2	9.1			27.3	9.1	18.2		18.2			
	Broilers	8.0	>64	-	-			4.5	4.5			18.2	22.7	22.7			27.3			
	Total	8.0	>64	-	-			2.7	8.1	2.7		16.2	24.3	18.9	5.4		21.6			
Erythromycin	Cattle	2.0	4.0	0.0	0.00-60.24		25.0				25.0	50.0								
	Pigs	2.0	16.0	45.5	16.74-76.63		18.2	9.1			27.3		27.3	9.1				9.1		
	Broilers	4.0	>128	27.3	10.72-50.23		9.1			13.6	13.6	36.4	4.5	4.5				18.2		
	Total	4.0	>128	29.7	15.85-47.06		13.5	2.7		8.1	18.9	27.0	10.8	5.4				13.5		
Tylosin	Cattle	2.0	8.0	0.0	0.00-60.24						50.0	25.0	25.0							
	Pigs	8.0	>256	18.2	2.28-51.78						18.2	18.2	45.5						18.2	
	Broilers	8.0	>256	27.3	10.72-50.23					4.5	18.2	18.2	27.3		4.5				27.3	
	Total	8.0	>256	21.6	9.82-38.22					2.7	21.6	18.9	32.4		2.7				21.6	
Lincomycin	Cattle	0.3	16.0	0.0	0.00-60.24			50.0					25.0	25.0						
	Pigs	32.0	>256	27.3	6.02-60.98				18.2			9.1		9.1	36.4			9.1	18.2	
	Broilers	32.0	256.0	27.3	10.72-50.23		4.5			9.1				31.8	22.7	4.5	9.1	9.1	9.1	
	Total	32.0	>256	24.3	11.77-41.20		2.7	5.4	5.4	5.4		2.7	2.7	24.3	24.3	2.7	5.4	8.1	10.8	
Enrofloxacin	Cattle	0.5	1.0	0.0	0.00-60.24				50.0	50.0										
	Pigs	1.0	4.0	27.3	6.02-60.98			9.1	36.4	27.3		18.2	9.1							
	Broilers	1.0	4.0	18.2	5.18-40.29			4.5	40.9	9.1	27.3	9.1	9.1							
	Total	1.0	4.0	18.9	7.95-35.21			5.4	40.5	18.9	16.2	10.8	8.1							
Salinomycin	Cattle	2.0	2.0	-	-					25.0	75.0									
	Pigs	2.0	4.0	-	-						81.8	18.2								
	Broilers	2.0	8.0	-	-					27.3	31.8	27.3	13.6							
	Total	2.0	4.0	-	-					18.9	51.4	21.6	8.1							
Vancomycin	Cattle	0.5	2.0	0.0	0.00-60.24				75.0		25.0									
	Pigs	0.5	2.0	0.0	0.00-28.50				81.8		9.1	9.1								
	Broilers	0.5	2.0	0.0	0.00-15.44			9.1	59.1	13.6	18.2									
	Total	0.5	2.0	0.0	0.00-9.49			5.4	67.6	8.1	16.2	2.7								

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.4.1. Distribution of MICs and resistance(%) in *Campylobacter jejuni* from cattle(n=81) and broilers(n=68) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	4.0	8.0	7.4	2.76-15.43				1.2		18.5	25.9	29.6	16.0	1.2	1.2	4.9	1.2		
	Pigs				-															
	Broilers	4.0	64.0	16.2	8.36-27.11				1.5			5.9	44.1	23.5	8.8	2.9	10.3		1.5	1.5
	Total	4.0	32.0	11.4	6.78-17.64				1.3		10.1	16.8	36.2	19.5	4.7	2.0	7.4	0.7	0.7	0.7
Gentamicin	Cattle	1.0	1.0	-	-			1.2		28.4	63.0	6.2		1.2						
	Broilers	0.5	1.0	-	-				17.6	41.2	36.8	2.9				1.5				
	Total	1.0	1.0	-	-			0.7	8.1	34.2	51.0	4.7		0.7		0.7				
Streptomycin	Cattle	1.0	2.0	6.2	2.03-13.83					13.6	54.3	24.7	1.2				1.2		4.9	
	Broilers	1.0	16.0	8.8	3.3-18.23					11.8	45.6	26.5	2.9	1.5	2.9	1.5	1.5		5.9	
	Total	1.0	4.0	7.4	3.74-12.83					12.8	50.3	25.5	2.0	0.7	1.3	0.7	1.3		5.4	
Erythromycin	Cattle	0.5	2.0	0.0	-				11.1	63.0	14.8	7.4	1.2	1.2	1.2					
	Broilers	0.5	2.0	0.0	-			4.4	7.4	39.7	29.4	16.2	2.9							
	Total	0.5	2.0	0.0	-			2.0	9.4	52.3	21.5	11.4	2.0	0.7	0.7					
Tetracycline	Cattle	>64	>64	63.0	51.51-73.44		12.3	18.5	3.7	1.2				1.2		2.5	6.2	54.3		
	Broilers	0.3	>64	33.8	22.78-46.32		22.1	20.6	11.8	2.9	2.9	2.9	1.5	1.5			11.8	22.1		
	Total	8.0	>64	49.7	41.37-57.97		16.8	19.5	7.4	2.0	1.3	1.3	0.7	1.3		1.3	8.7	39.6		
Nalidixic acid	Cattle	8.0	>128	45.7	34.55-57.1			1.2				13.6	29.6	8.6	1.2	1.2	1.2	16.0	27.2	
	Broilers	64.0	>128	57.4	44.76-69.3						1.5	4.4	20.6	8.8	7.4	5.9	2.9	16.2	32.4	
	Total	32.0	>128	51.0	42.69-59.3			0.7			0.7	9.4	25.5	8.7	4.0	3.4	2.0	16.1	29.5	
Ciprofloxacin	Cattle	0.3	16.0	44.4	33.39-55.92	1.2	2.5	27.2	22.2		1.2	1.2	1.2	14.8	24.7	2.5	1.2			
	Broilers	4.0	16.0	51.5	39.02-63.78		1.5	14.7	19.1	10.3	2.9		1.5	16.2	26.5	4.4	2.9			
	Total	1.0	16.0	47.7	39.41-55.99	0.7	2.0	21.5	20.8	4.7	2.0	0.7	1.3	15.4	25.5	3.4	2.0			
Chloramphenicol	Cattle	2.0	4.0	3.7	0.77-10.45						48.1	38.3	8.6	1.2	2.5	1.2				
	Broilers	2.0	4.0	2.9	0.35-10.23						20.6	54.4	17.6	4.4	1.5	1.5				
	Total	2.0	4.0	3.4	1.09-7.66						35.6	45.6	12.8	2.7	2.0	1.3				

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.4.2. Distribution of MICs and resistance(%) in *Campylobacter jejuni* from cattle(n=97) and broilers(n=67) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	4.0	16.0	8.2	3.62-15.61						7.2	19.6	39.2	17.5	8.2	2.1	5.2	1.0		
	Pigs				-															
	Broilers	4.0	64.0	28.4	18.01-40.7					4.5	11.9	6.0	32.8	13.4	3.0	9.0	13.4	4.5	1.5	
	Total	4.0	64.0	16.5	11.13-23.05					1.8	9.1	14.0	36.6	15.9	6.1	4.9	8.5	2.4	0.6	
Gentamicin	Cattle	0.5	1.0	-	-				6.2	52.6	41.2									
	Broilers	0.5	1.0	-	-				7.5	50.7	40.3	1.5								
	Total	0.5	1.0	-	-				6.7	51.8	40.9	0.6								
Streptomycin	Cattle	1.0	2.0	4.1	1.13-10.23			3.1	17.5	28.9	26.8	19.6					1.0	1.0	2.1	
	Broilers	1.0	1.0	1.5	0.03-8.04				10.4	34.3	46.3	7.5							1.5	
	Total	1.0	2.0	3.0	0.99-6.98			1.8	14.6	31.1	34.8	14.6					0.6	0.6	1.8	
Azithromycin	Cattle	0.06	0.12	0.0	0-3.74	3.1	66.0	22.7	6.2	1.0		1.0								
	Broilers	0.06	0.12	1.5	0.03-8.04	28.4	58.2	10.4	1.5									1.5		
	Total	0.06	0.12	0.6	0.01-3.36	13.4	62.8	17.7	4.3	0.6		0.6						0.6		
Erythromycin	Cattle	0.5	2.0	0.0	0-3.74			2.1	14.4	51.5	14.4	12.4	4.1	1.0						
	Broilers	0.25	1.0	1.5	0.03-8.04			11.9	40.3	29.9	13.4	3.0				1.5				
	Total	0.5	2.0	0.6	0.01-3.36			6.1	25.0	42.7	14.0	8.5	2.4	0.6		0.6				
Tetracycline	Cattle	64.0	>64	72.2	62.14-80.79		9.3	18.6							1.0	7.2	17.5	46.4		
	Broilers	0.25	64.0	46.3	33.99-58.89		17.9	19.4	13.4	1.5				1.5	4.5	16.4	17.9	7.5		
	Total	32.0	>64	61.6	53.68-69.07		12.8	18.9	5.5	0.6				0.6	2.4	11.0	17.7	30.5		
Nalidixic acid	Cattle	16.0	>128	48.5	38.16-58.86							7.2	25.8	9.3	9.3	2.1	14.4	11.3	20.6	
	Broilers	8.0	128.0	46.3	33.99-58.89							11.9	31.3	10.4		11.9	20.9	11.9	1.5	
	Total	16.0	>128	47.6	39.71-55.5							9.1	28.0	9.8	5.5	6.1	17.1	11.6	12.8	
Ciprofloxacin	Cattle	4.0	16.0	50.5	40.17-60.83		2.1	24.7	18.6	3.1	1.0		1.0	19.6	22.7	5.2	2.1			
	Broilers	0.5	16.0	44.8	32.6-57.43		1.5	25.4	19.4	9.0			3.0	25.4	14.9	1.5				
	Total	0.5	16.0	48.2	40.31-56.1		1.8	25.0	18.9	5.5	0.6		1.8	22.0	19.5	3.7	1.2			
Chloramphenicol	Cattle	2.0	4.0	6.2	2.3-12.98					2.1	38.1	40.2	11.3	2.1		2.1	3.1	1.0		
	Broilers	1.0	2.0	0.0	0-5.36				1.5	10.4	52.2	31.3	4.5							
	Total	1.0	4.0	3.7	1.35-7.8				0.6	5.5	43.9	36.6	8.5	1.2		1.2	1.8	0.6		

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.5.1. Distribution of MICs and resistance(%) in *Campylobacter coli* from cattle(n=88), pigs(n=39) and broilers(n=14) in 2016_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	8.0	16.0	4.5	1.25-11.24						1.1	1.1	9.1	46.6	37.5	3.4	1.1			
	Pigs	8.0	64.0	15.4	5.86-30.53						5.1	10.3	33.3	35.9		5.1	5.1		2.6	2.6
	Broilers	4.0	16.0	7.1	0.18-33.87						7.1	7.1	57.1	14.3	7.1				7.1	
	Total	8.0	16.0	7.8	3.95-13.54						2.8	4.3	20.6	40.4	24.1	3.5	2.1		1.4	0.7
Gentamicin	Cattle	1.0	2.0	-	-					1.1	67.0	29.5	2.3							
	Pigs	1.0	2.0	-	-					15.4	66.7	17.9								
	Broilers	1.0	1.0	-	-						100.0									
	Total	1.0	2.0	-	-					5.0	70.2	23.4	1.4							
Streptomycin	Cattle	2.0	8.0	5.7	1.87-12.77						10.2	40.9	18.2	21.6	3.4				5.7	
	Pigs	64.0	>128	64.1	47.05-78.98							15.4	20.5				23.1	17.9	23.1	
	Broilers	4.0	>128	42.9	17.66-71.14							42.9	14.3				7.1	7.1	28.6	
	Total	4.0	>128	25.5	18.56-33.56						6.4	34.0	18.4	13.5	2.1		7.1	5.7	12.8	
Erythromycin	Cattle	4.0	4.0	5.7	-						8.0	31.8	51.1	3.4			1.1	4.5		
	Pigs	4.0	128.0	38.5	-					7.7	2.6	30.8	15.4	5.1				38.5		
	Broilers	0.5	128.0	28.6	-				7.1	42.9	14.3	7.1						28.6		
	Total	4.0	128.0	17.0	-				0.7	6.4	7.1	29.1	36.2	3.5			0.7	16.3		
Tetracycline	Cattle	128.0	128.0	67.0	56.2-76.7			3.4	17.0	11.4	1.1						2.3	64.8		
	Pigs	128.0	128.0	89.7	75.25-97.45			5.1	5.1						2.6	12.8	10.3	64.1		
	Broilers	0.5	128.0	35.7	12.75-64.87			7.1	7.1	42.9			7.1					35.7		
	Total	128.0	128.0	70.2	61.93-77.62			4.3	12.8	11.3	0.7		0.7		0.7	3.5	4.3	61.7		
Nalidixic acid	Cattle	128.0	>128	75.0	64.63-83.63								1.1	21.6	2.3		8.0	27.3	39.8	
	Pigs	64.0	>128	61.5	44.51-76.81								15.4	12.8	10.3	5.1	12.8	25.6	17.9	
	Broilers	128.0	>128	78.6	49.2-95.35									14.3	7.1		7.1	35.7	35.7	
	Total	128.0	>128	71.6	63.4-78.94								5.0	18.4	5.0	1.4	9.2	27.7	33.3	
Ciprofloxacin	Cattle	16.0	32.0	75.0	64.63-83.63				21.6	3.4				3.4	42.0	21.6	8.0			
	Pigs	8.0	32.0	59.0	42.09-74.44			7.7	23.1	5.1	5.1			25.6	17.9	10.3	5.1			
	Broilers	16.0	32.0	71.4	41.89-91.62			7.1	21.4						57.1	7.1	7.1			
	Total	16.0	32.0	70.2	61.93-77.62			2.8	22.0	3.5	1.4			9.2	36.9	17.0	7.1			
Chloramphenicol	Cattle	4.0	4.0	4.5	1.25-11.24						5.7	38.6	47.7	3.4	1.1		1.1	2.3		
	Pigs	4.0	32.0	15.4	5.86-30.53						5.1	35.9	33.3	10.3	2.6	5.1	7.7			
	Broilers	4.0	32.0	14.3	1.77-42.82							35.7	50.0			7.1	7.1			
	Total	4.0	8.0	8.5	4.47-14.4						5.0	37.6	44.0	5.0	1.4	2.1	3.5	1.4		

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.5.2. Distribution of MICs and resistance(%) in *Campylobacter coli* from cattle(n=59), pigs(n=61) and broilers(n=10) in 2017_Slaughterhouse

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	8.0	8.0	0.0	0-6.07							1.7	13.6	83.1	1.7					
	Pigs	8.0	64.0	29.5	18.51-42.57				1.6	1.6	8.2	14.8	19.7	23.0	1.6	4.9	23.0	1.6		
	Broilers	4.0	128.0	20.0	2.52-55.61								60.0	20.0				10.0	10.0	
	Total	8.0	64.0	15.4	9.65-22.76				0.8	0.8	3.8	7.7	20.0	50.0	1.5	2.3	10.8	1.5	0.8	
Gentamicin	Cattle	1.0	2.0	-	-					16.9	59.3	22.0	1.7							
	Pigs	1.0	2.0	-	-					3.3	55.7	41.0								
	Broilers	1.0	2.0	-	-					20.0	60.0	20.0								
	Total	1.0	2.0	-	-					10.8	57.7	30.8	0.8							
Streptomycin	Cattle	2.0	8.0	3.4	0.41-11.72						28.8	33.9	13.6	18.6	1.7		1.7	1.7		
	Pigs	128.0	>128	68.9	55.7-80.1						1.6	8.2	18.0	3.3			9.8	19.7	39.3	
	Broilers	2.0	>128	50.0	18.7-81.3					10.0	20.0	20.0						10.0	40.0	
	Total	4.0	>128	37.7	29.34-46.62					0.8	15.4	20.8	14.6	10.0	0.8		5.4	10.8	21.5	
Azithromycin	Cattle	0.25	0.3	0.0	0-6.07		5.1	37.3	54.2	3.4										
	Pigs	0.25	>64	31.1	19.9-44.3		9.8	29.5	26.2	3.3							1.6	29.5		
	Broilers	0.12	>64	50.0	18.7-81.3	20.0	10.0	20.0										50.0		
	Total	0.25	>64	18.5	12.2-26.22	1.5	7.7	32.3	36.9	3.1							0.8	17.7		
Erythromycin	Cattle	2.0	4.0	0.0	0-6.07						6.8	54.2	37.3	1.7						
	Pigs	2.0	128.0	31.1	19.9-44.3				1.6	13.1	24.6	29.5					3.3	27.9		
	Broilers	2.0	128.0	50.0	18.7-81.3			10.0	10.0	10.0		20.0					20.0	30.0		
	Total	2.0	128.0	18.5	12.2-26.22			0.8	1.5	6.9	14.6	40.0	16.9	0.8			3.1	15.4		
Tetracycline	Cattle	>64	>64	79.7	67.16-89.03			16.9	3.4							3.4	15.3	61.0		
	Pigs	64.0	>64	83.6	71.72-92.01			6.6	4.9	1.6		1.6		1.6	6.6	13.1	29.5	34.4		
	Broilers	16.0	>64	60.0	26.23-87.85		20.0	20.0							20.0		10.0	30.0		
	Total	64.0	>64	80.0	72.03-86.55		1.5	12.3	3.8	0.8		0.8		0.8	4.6	7.7	21.5	46.2		
Nalidixic acid	Cattle	64.0	128.0	79.7	67.16-89.03								6.8	10.2	3.4	6.8	28.8	42.4	1.7	
	Pigs	32.0	128.0	50.8	37.69-63.87								11.5	24.6	13.1	14.8	18.0	14.8	3.3	
	Broilers	32.0	>128	70.0	34.75-93.33								10.0	20.0		20.0	20.0	10.0	20.0	
	Total	64.0	128.0	65.4	56.54-73.51								9.2	17.7	7.7	11.5	23.1	26.9	3.8	
Ciprofloxacin	Cattle	16.0	16.0	81.4	68.91-90.47				16.9	1.7			1.7	13.6	61.0	5.1				
	Pigs	4.0	32.0	54.1	40.8-67.01			11.5	19.7	13.1	1.6		8.2	11.5	19.7	9.8	4.9			
	Broilers	4.0	64.0	70.0	34.75-93.33			20.0	10.0				30.0	10.0	10.0		10.0	10.0		
	Total	8.0	32.0	67.7	58.9-75.66			6.9	17.7	6.9	0.8		6.9	12.3	37.7	6.9	3.1	0.8		
Chloramphenicol	Cattle	2.0	4.0	6.8	1.87-16.46						13.6	50.8	28.8			5.1	1.7			
	Pigs	2.0	4.0	1.6	0.04-8.8					9.8	14.8	41.0	32.8			1.6				
	Broilers	2.0	4.0	0.0	0-30.85						40.0	30.0	30.0							
	Total	2.0	4.0	3.8	1.26-8.75					4.6	16.2	44.6	30.8			3.1	0.8			

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.6.1. Distribution of MICs and resistance(%) in *Salmonella* from broilers(n=104) in 2016_Slaughterhouse

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	2.0	>128	13.5	7.55-21.56						44.2	39.4	2.9					1.9	11.5	
Cefazolin	2.0	4.0	7.7	3.37-14.60						18.3	69.2	4.8	4.8	1.0				1.9	
Cefotaxime	0.12	0.12	1.9	0.23-6.78			93.3	3.8	1.0				1.9						
Streptomycin	32.0	64.0	77.9	68.68-85.44						1.0		1.0	12.5	7.7	42.3	26.9	6.7	1.9	
Gentamicin	≦0.5	≦0.5	0.0	0.00-3.49					94.2	5.8									
Kanamycin	>128	>128	72.1	62.46-80.47						13.5	11.5	1.0	1.0		1.0			72.1	
Tetracycline	64.0	64.0	82.7	74.03-89.41						9.6	7.7				1.9	76.0	4.8		
Nalidixic acid	4.0	>128	12.5	6.82-20.43							1.0	73.1	13.5					12.5	
Ciprofloxacin	≦0.03	0.25	0.0	0.00-3.49	82.7	3.8	1.0	10.6	1.9										
Colistin	1.0	2.0	0.0	0.00-3.49				7.7	28.8	45.2	18.3								
Chloramphenicol	4.0	8.0	0.0	0.00-3.49							1.9	55.8	41.3	1.0					

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs									
							2.38/0.12	4.75/0.25	9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	>8	>8	56.7	46.65-66.42			21.2	16.3	5.8					56.7

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.6.2. Distribution of MICs and resistance(%) in *Salmonella* from broilers(n=112) in 2017_Slaughterhouse

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	≦1	2.0	8.0	3.74-14.71						55.4	34.8	1.8					1.8	6.3	
Cefazolin	2.0	2.0	3.6	0.98-8.90						18.8	75.0	2.7	1.8					1.8	
Cefotaxime	0.12	0.12	1.8	0.21-6.31			96.4	1.8				0.9	0.9						
Streptomycin	32.0	64.0	60.7	51.03-69.81								8.0	8.9	22.3	43.8	16.1		0.9	
Gentamicin	≦0.5	≦0.5	0.0	0.00-3.24					93.8	5.4	0.9								
Kanamycin	>128	>128	73.2	64.01-81.15						16.1	7.1		0.9	1.8	0.9	0.9	0.9	71.4	
Tetracycline	64.0	64.0	77.7	68.83-85.01						3.6	18.8				2.7	73.2	1.8		
Nalidixic acid	4.0	>128	17.0	10.53-25.22							0.9	74.1	5.4	2.7	1.8			15.2	
Ciprofloxacin	≦0.03	0.25	0.0	0.00-3.24	80.4	0.9	4.5	9.8	4.5										
Colistin	1.0	2.0	0.0	0.00-3.24				6.3	17.9	44.6	31.3								
Chloramphenicol	4.0	8.0	0.9	0.02-4.88						0.9	13.4	72.3	10.7	1.8				0.9	

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs							
					2.38/0.12	4.75/0.25	9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	>8	>8	55.4	45.66-64.76	30.4	9.8	4.5				1.8	53.6

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.7.1. Distribution of MICs and resistance(%) in *Salmonella* fromcattle(n=70) and pigs(n=56) in 2016_Farm

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	4.0	>128	50.0	37.80-62.20						20.0	28.6	1.4						50.0	
	Pigs	2.0	>128	41.1	28.09-55.03						17.9	32.1	8.9					1.8	39.3	
	Total	4.0	>128	46.0	37.11-55.14						19.0	30.2	4.8					0.8	45.2	
Cefazolin	Cattle	2.0	8.0	22.9	13.66-34.45						34.3	18.6	24.3	15.7	2.9				4.3	
	Pigs	2.0	8.0	23.2	12.97-36.42						32.1	33.9	10.7	17.9	5.4					
	Total	2.0	8.0	23.0	15.98-31.36						33.3	25.4	18.3	16.7	4.0				2.4	
Cefotaxime	Cattle	≦0.5	≦0.5	4.3	0.89-12.02					95.7							1.4	2.9		
	Pigs	≦0.5	≦0.5	0.0	0.00-6.38					100.0										
	Total	≦0.5	≦0.5	2.4	0.49-6.81					97.6							0.8	1.6		
Streptomycin	Cattle	16.0	>128	-	-									10.0	48.6	1.4		2.9	37.1	
	Pigs	64.0	>128	-	-									10.7	32.1	5.4	5.4		46.4	
	Total	16.0	>128	-	-									10.3	41.3	3.2	2.4	1.6	41.3	
Gentamicin	Cattle	≦0.5	1.0	4.3	0.89-12.02					84.3	11.4					1.4		2.9		
	Pigs	≦0.5	32.0	17.9	8.91-30.40					69.6	12.5				3.6	5.4		8.9		
	Total	≦0.5	16.0	10.3	5.60-17.00					77.8	11.9				1.6	3.2		5.6		
Kanamycin	Cattle	4.0	>128	25.7	16.00-37.57							37.1	32.9	2.9		1.4			25.7	
	Pigs	4.0	>128	10.7	4.03-21.88							30.4	44.6	10.7	3.6				10.7	
	Total	4.0	>128	19.0	12.60-27.01							34.1	38.1	6.3	1.6	0.8			19.0	

Table 12.7.1. Distribution of MICs and resistance(%) in *Salmonella* fromcattle(n=70) and pigs(n=56) in 2016_Farm

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Tetracycline	Cattle	2.0	>64	42.9	31.08-55.26						20.0	37.1				4.3		38.6		
	Pigs	64.0	>64	58.9	44.97-71.91						10.7	26.8	1.8	1.8	5.4	1.8	8.9	42.9		
	Total	8.0	>64	50.0	40.96-59.04						15.9	32.5	0.8	0.8	2.4	3.2	4.0	40.5		
Nalidixic acid	Cattle	4.0	8.0	5.7	1.57-13.99								62.9	28.6	2.9				5.7	
	Pigs	4.0	16.0	7.1	1.98-17.30							3.6	51.8	28.6	8.9				7.1	
	Total	4.0	16.0	6.3	2.78-12.13							1.6	57.9	28.6	5.6				6.3	
Ciprofloxacin	Cattle	≦0.03	≦0.03	0.0	0.00-5.14	90.0	4.3			5.7										
	Pigs	≦0.03	0.5	0.0	0.00-6.38	82.1	3.6			10.7	3.6									
	Total	≦0.03	0.06	0.0	0.00-2.89	86.5	4.0			7.9	1.6									
Colistin	Cattle	0.5	1.0	1.4	0.03-7.82				24.6	62.3	10.1	1.4	1.4							
	Pigs	0.5	1.0	3.6	0.44-12.53			3.6	38.2	43.6	9.1	1.8	3.6							
	Total	0.5	1.0	2.4	0.50-6.91			1.6	30.6	54.0	9.7	1.6	2.4							
Chloramphenicol	Cattle	8.0	>128	12.9	6.05-23.01									77.1	10.0				12.9	
	Pigs	8.0	16.0	8.9	2.96-19.62								26.8	58.9	5.4			3.6	5.4	
	Total	8.0	128.0	11.1	6.20-17.94								11.9	69.0	7.9			1.6	9.5	
Trimethoprim	Cattle	≦0.25	0.5	4.3	0.89-12.02				54.3	35.7	5.7					4.3				
	Pigs	≦0.25	>16	21.4	11.59-34.44				58.9	14.3	5.4					21.4				
	Total	≦0.25	>16	11.9	6.81-18.88				56.3	26.2	5.6					11.9				

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.7.2. Distribution of MICs and resistance(%) in *Salmonella* fromcattle(n=59) and pigs(n=44) in 2017_Farm

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	Cattle	2.0	>128	40.7	28.06-54.26						35.6	20.3	3.4						40.7	
	Pigs	2.0	>128	40.9	26.30-56.84						25.0	31.8	2.3						40.9	
	Total	2.0	>128	40.8	31.18-50.93						31.1	25.2	2.9						40.8	
Cefazolin	Cattle	2.0	4.0	5.1	1.06-14.15						35.6	33.9	25.4	3.4					1.7	
	Pigs	2.0	4.0	6.8	1.42-18.66						34.1	36.4	22.7	4.5	2.3					
	Total	2.0	4.0	5.8	2.16-12.25						35.0	35.0	24.3	3.9	1.0				1.0	
Cefotaxime	Cattle	0.12	0.25	1.7	0.04-9.09			69.5	28.8							1.7				
	Pigs	0.12	0.25	0.0	0.00-8.05			79.5	15.9	4.5										
	Total	0.12	0.25	1.0	0.02-5.30			73.8	23.3	1.9						1.0				
Streptomycin	Cattle	16.0	>128	-	-									22.0	39.0		1.7	3.4	33.9	
	Pigs	32.0	>128	-	-									2.3	38.6	11.4	6.8		40.9	
	Total	16.0	>128	-	-									13.6	38.8	4.9	3.9	1.9	36.9	
Gentamicin	Cattle	≦0.5	1.0	1.7	0.04-9.09					84.7	13.6					1.7				
	Pigs	≦0.5	16.0	15.9	6.64-30.07					75.0	6.8	2.3			9.1	2.3		4.5		
	Total	≦0.5	1.0	7.8	3.41-14.74					80.6	10.7	1.0			3.9	1.9		1.9		
Kanamycin	Cattle	2.0	4.0	5.1	1.06-14.15						3.4	54.2	33.9	3.4			1.7	1.7	1.7	
	Pigs	4.0	>128	13.6	5.17-27.36							34.1	38.6	11.4	2.3				13.6	
	Total	4.0	8.0	8.7	4.07-15.94						1.9	45.6	35.9	6.8	1.0		1.0	1.0	6.8	

Table 12.7.2. Distribution of MICs and resistance(%) in *Salmonella* fromcattle(n=59) and pigs(n=44) in 2017_Farm

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
						0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Tetracycline	Cattle	2.0	>64	39.0	26.52-52.61						28.8	30.5	1.7				5.1	33.9		
	Pigs	4.0	>64	50.0	34.56-65.44						6.8	40.9	2.3				11.4	38.6		
	Total	2.0	>64	43.7	33.93-53.82						19.4	35.0	1.9				7.8	35.9		
Nalidixic acid	Cattle	4.0	8.0	5.1	1.06-14.15								50.8	42.4	1.7			1.7	3.4	
	Pigs	4.0	16.0	9.1	2.53-21.67								50.0	29.5	11.4	2.3			6.8	
	Total	4.0	16.0	6.8	2.77-13.51								50.5	36.9	5.8	1.0		1.0	4.9	
Ciprofloxacin	Cattle	≦0.03	0.06	1.7	0.04-9.09	74.6	20.3		3.4		1.7									
	Pigs	≦0.03	0.5	4.5	0.55-15.48	68.2	13.6		6.8	6.8	4.5									
	Total	≦0.03	0.25	2.9	0.60-8.28	71.8	17.5		4.9	2.9	2.9									
Colistin	Cattle	0.3	1.0	5.1	1.06-14.15				61.0	20.3	10.2	3.4	5.1							
	Pigs	0.3	1.0	4.5	0.55-15.48				50.0	31.8	9.1	4.5	2.3	2.3						
	Total	0.3	1.0	4.9	1.59-10.97				56.3	25.2	9.7	3.9	3.9	1.0						
Chloramphenicol	Cattle	8.0	8.0	3.4	0.41-11.72								1.7	93.2	1.7				3.4	
	Pigs	8.0	>128	18.2	8.19-32.72								22.7	52.3	6.8			4.5	13.6	
	Total	8.0	16.0	9.7	4.75-17.14								10.7	75.7	3.9			1.9	7.8	

Antimicrobial agent	Animal species	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs							
						2.38/0.12	4.75/0.25	9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	Cattle	2.38/0.12	4.75/0.25	3.4	0.41-11.72	55.9	35.6	3.4	1.7				3.4
	Pigs	4.75/0.25	>152/8	25.0	13.19-40.34	34.1	18.2	15.9	2.3	4.5			25.0
	Total	4.75/0.25	16.0	12.6	6.89-20.62	46.6	28.2	8.7	1.9	1.9			12.6

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.8. *Salmonella* serovars isolated from food-producing animals in 2016 and 2017

Serovar	Farm								Slaughterhouse			
	Cattle			Pigs			Total	Rate(%)	Chickens		Total	Rate(%)
	2016	2017	subtotal	2016	2017	subtotal			2016	2017		
Typhimurium	28	5	33	22	24	46	79	34.5	10	8	18	8.3
O4:i:-	15	21	36	14	9	23	59	25.8	0	0	0	0.0
Choleraesuis	0	0	0	7	5	12	12	5.2	0	0	0	0.0
Infantis	10	5	15	3	0	3	18	7.9	16	21	37	17.1
Schwarzengrund	0	2	2	0	1	1	3	1.3	69	80	149	69.0
Manhattan	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Derby	0	0	0	3	0	3	3	1.3	0	0	0	0.0
Give	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Mbandaka	1	1	2	0	1	1	3	1.3	0	0	0	0.0
Rissen	0	0	0	1	1	2	2	0.9	0	0	0	0.0
Newport	0	2	2	0	1	1	3	1.3	0	0	0	0.0
Bareilly	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Braenderup	0	3	3	0	0	0	3	1.3	0	0	0	0.0
Livingstone	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Tennessee	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Thompson	1	5	6	0	0	0	6	2.6	2	1	3	1.4
Stanley	8	2	10	0	0	0	10	4.4	0	0	0	0.0
Ⅱ (Sofia)	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Enteritidis	0	1	1	0	0	0	1	0.4	0	0	0	0.0
Blockley	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Cerro	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Dublin	0	2	2	0	0	0	2	0.9	0	0	0	0.0
Montevideo	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Oranienburg	0	0	0	0	0	0	0	0.0	0	0	0	0.0
Othmarschen	1	0	1	0	0	0	1	0.4	0	0	0	0.0
Senftenberg	0	0	0	0	0	0	0	0.0	0	0	0	0.0
others	6	10	16	6	2	8	24	10.5	7	2	9	4.2
Total	70	59	129	56	44	100	229	100.0	104	112	216	100

Table 12.9.1. Distribution of MICs and resistance(%) in *Escherichia coli* from dogs(n=199), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	>128	>128	55.3	48.08-62.32								33.7	9.5	1.5		1.0	1.5	52.8	
Cefazolin	≦4	>128	31.2	24.79-38.09								66.3	2.0	0.5	4.0	0.5	0.5	26.1	
Cefalexin	8	>128	31.7	25.26-38.62								14.1	45.7	8.5	1.5		2.5	27.6	
Cefotaxime	≦0.5	64	26.1	20.17-31.82					71.4	1.5	1.0	1.5	1.5	3.5	5.0	6.0	8.5		
Meropenem	≦0.25	≦0.25	0.0	0.00-1.84				100.0											
Streptomycin	8	>128	29.6	23.39-36.52								29.1	37.7	3.5	2.0	4.0	6.0	17.6	
Gentamicin	≦2	64	14.1	9.55-19.69							85.4		0.5	0.5	2.0	7.0	4.5		
Kanamycin	≦4	16	6.5	3.52-10.92								75.4	14.6	2.5	1.0	1.0	0.5	5.0	
Tetracycline	2	>64	28.1	22.01-34.94							61.8	9.5	0.5	0.5	1.0	12.6	14.1		
Nalidixic acid	>128	>128	61.8	54.67-68.59								34.2	1.0	3.0			3.0	58.8	
Ciprofloxacin	0.5	>4	43.2	36.22-50.41	33.2	2.0	4.0	10.6	5.5	1.0	0.5	2.0	41.2						
Colistin	≦0.5	≦0.5	1.0	0.12-3.59					96.5	2.0	0.5	0.5			0.5				
Chloramphenicol	8	32	12.6	8.29-17.99								13.1	57.8	16.6	4.0	2.5	1.0	5.0	

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs					
					≦9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	≦9.5/0.5	>152/8	24.6	18.80-31.22	73.4	1.5	0.5			24.6

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.9.2. Distribution of MICs and resistance(%) in *Escherichia coli* from cats(n=136), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	>256
Ampicillin	>128	>128	64.0	55.29-72.02								31.6	4.4		0.7	3.7	1.5	58.1	
Cefazolin	≦4	>128	37.5	29.35-46.21								54.4	4.4	3.7	2.9			34.6	
Cefalexin	8	>128	41.9	33.50-50.69								16.9	36.0	5.1	1.5	2.2	5.1	33.1	
Cefotaxime	≦0.5	64	33.8	25.93-42.43					64.0	1.5	0.7	1.5	2.9	4.4	11.0	5.9	8.1		
Meropenem	≦0.25	≦0.25	0.0	0.00-2.68				100.0											
Streptomycin	8	>128	32.4	24.58-40.91								25.0	38.2	4.4	2.2	2.9	5.1	22.1	
Gentamicin	≦2	64	12.5	7.45-19.26							87.5				0.7	3.7	8.1		
Kanamycin	≦4	16	8.1	4.10-14.02								77.9	6.6	5.9	1.5			8.1	
Tetracycline	≦2	>64	24.3	17.32-32.36							66.9	8.1	0.7	0.7	1.5	8.1	14.0		
Nalidixic acid	>128	>128	58.8	50.06-67.19								37.5	3.7		0.7	2.9	2.2	52.9	
Ciprofloxacin	0.5	>4	39.0	30.73-47.71	38.2	2.2	5.1	8.8	5.1	1.5		0.7	38.2						
Colistin	≦0.5	≦0.5	0.0	0.00-2.68					99.3		0.7								
Chloramphenicol	8	128	13.2	8.03-20.11								12.5	60.3	14.0	0.7	2.2	2.9	7.4	

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs					
					≦9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	≦9.5/0.5	>152/8	22.1	15.40-29.97	75.0	1.5	1.5	0.7		21.3

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.10.1. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from dogs(n=90) in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	1.0	1.0	1.1	0.02-6.04				18.9	78.9		1.1					1.1			
Cefazolin	16.0	32.0	-	-							2.2	2.2	72.2	20.0	1.1	2.2			
Cefalexin	64.0	>64	-	-									1.1		62.2	36.7			
Cefmetazole	>64	>64	-	-								1.1				98.9			
Cefotaxime	>64	>64	-	-				1.1	1.1					5.6	14.4	77.8			
Streptomycin	64.0	>128	-	-									5.6	34.4	30.0	11.1	18.9		
Gentamicin	4.0	>64	18.9	11.4-28.52						16.7	38.9	17.8	7.8	2.2	4.4	12.2			
Tetracycline	32.0	64.0	70.0	59.42-79.22				26.7	2.2			1.1	1.1	25.6	40.0	3.3			
Erythromycin	>64	>64	53.3	42.51-63.93			8.9	3.3	8.9	22.2	3.3	1.1			52.2				
Azithromycin	>64	>64	-	-			2.2	1.1	7.8	6.7	18.9	10.0	1.1		52.2				
Chloramphenicol	8.0	32.0	24.4	15.99-34.64							30.0	40.0	5.6	15.6	6.7	2.2			
Nalidixic acid	>32	>32	-	-										2.2	97.8				
Ciprofloxacin	1.0	>16	18.9	11.4-28.52			1.1	12.2	56.7	11.1		11.1	6.7	1.1					

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.10.2. Distribution of MICs and resistance(%) in *Enterococcus faecalis* from Cats(n=72) in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	1.0	1.0	1.4	0.03-7.5				23.6	69.4	5.6					1.4				
Cefazolin	16.0	32.0	-	-								5.6	63.9	29.2		1.4			
Cefalexin	>64	>64	-	-										1.4	47.2	51.4			
Cefmetazole	>64	>64	-	-											1.4	98.6			
Cefotaxime	>64	>64	-	-				1.4		1.4		5.6	1.4	2.8	6.9	80.6			
Streptomycin	32.0	128.0	-	-							1.4	4.2	13.9	33.3	34.7	2.8	9.7		
Gentamicin	8.0	64.0	13.9	6.86-24.07						20.8	27.8	31.9	5.6	1.4	5.6	6.9			
Tetracycline	32.0	64.0	72.2	60.4-82.14				22.2	2.8	1.4		1.4	1.4	20.8	50.0				
Erythromycin	2.0	>32	36.1	25.11-48.29			6.9	5.6	18.1	25.0	8.3	1.4			34.7				
Azithromycin	4.0	>32	-	-			5.6	1.4	2.8	9.7	36.1	8.3	1.4		34.7				
Chloramphenicol	8.0	32.0	23.6	14.39-35.1						1.4	19.4	50.0	5.6	13.9	8.3	1.4			
Nalidixic acid	>32	>32	-	-										1.4	98.6				
Ciprofloxacin	1.0	16.0	18.1	9.97-28.9				6.9	59.7	15.3	2.8	2.8	2.8	9.7					

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.11.1. Distribution of MICs and resistance(%) in *Enterococcus faecium* from dogs(n=29) in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	>64	>64	93.1	77.23-99.16								6.9	3.4	13.8	20.7	55.2			
Cefazolin	>64	>64	-	-									3.4			96.6			
Cefalexin	>64	>64	-	-												100.0			
Cefmetazole	>64	>64	-	-												100.0			
Cefotaxime	>64	>64	-	-										3.4		96.6			
Streptomycin	>128	>128	-	-								3.4	6.9	24.1	3.4		62.1		
Gentamicin	16.0	64.0	31.0	15.28-50.84						20.7	20.7	3.4	24.1	17.2	6.9	6.9			
Tetracycline	16.0	64.0	51.7	32.43-70.77				44.8				3.4	10.3	13.8	20.7	6.9			
Erythromycin	>32	>32	79.3	59.88-92.39				3.4		13.8	3.4	3.4		3.4	72.4				
Azithromycin	>32	>32	-	-					3.4		13.8	3.4			79.3				
Chloramphenicol	8.0	16.0	6.9	0.84-22.77							20.7	58.6	13.8	3.4		3.4			
Nalidixic acid	>32	>32	-	-											100.0				
Ciprofloxacin	>16	>16	100.0	88.05-100									3.4	96.6					

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.11.2. Distribution of MICs and resistance(%) in *Enterococcus faecium* from cats(n=19) in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs														
					0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Ampicillin	64.0	>64	84.2	60.42-96.62					10.5		5.3			31.6	10.5	42.1			
Cefazolin	>64	>64	-	-										10.5		89.5			
Cefalexin	>64	>64	-	-										10.5		89.5			
Cefmetazole	>64	>64	-	-								5.3			5.3	89.5			
Cefotaxime	>64	>64	-	-				5.3								94.7			
Streptomycin	>128	>128	-	-									15.8	21.1	5.3	10.5	47.4		
Gentamicin	16.0	>64	42.1	20.25-66.51						36.8	5.3	5.3	10.5	21.1		21.1			
Tetracycline	16.0	>64	57.9	33.49-79.75				36.8				5.3	10.5	21.1	15.8	10.5			
Erythromycin	>32	>32	63.2	38.35-83.72				5.3	5.3	15.8	10.5				63.2				
Azithromycin	>32	>32	-	-					5.3	5.3	15.8	10.5			63.2				
Chloramphenicol	8.0	16.0	5.3	0.13-26.03						5.3	21.1	57.9	10.5	5.3					
Nalidixic acid	>32	>32	-	-											100.0				
Ciprofloxacin	>16	>16	94.7	73.97-99.87				5.3					10.5	84.2					

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.12.1. Distribution of MICs and resistance(%) in *Staphylococcus pseudintermedius* from dogs (n=122), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs													
					0.03	0.06	≦0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	1	>16	-				16.4	19.7	9.8	10.7	9.0	8.2	6.6	9.0	10.7			
Oxacillin	0.5	>8	58.2	48.92 - 67.07			40.2	1.6	13.9	14.8	4.1	3.3	5.7	16.4				
Cefazolin	≦0.12	2	-				68.9	7.4	6.6	5.7	4.9	2.5	3.3	0.8				
Cefalexin	2	>8	-							48.4	13.9	9.8	7.4	20.5				
Cefoxitin	≦1	≦1	-							92.6	5.7	0.8	0.8					
Cefmetazole	≦1	≦1	0.0	0.00-2.98						98.4	1.6							
Cefotaxime	0.25	4	-				45.9	13.1	9.8	10.7	7.4	6.6	2.5	4.1				
Streptomycin	128	>128	-									32.0	0.8		1.6	4.1	16.4	45.1
Gentamicin	8	16	26.2	18.67 - 34.98					27.0	1.6	1.6	3.3	40.2	21.3	4.1	0.8		
Tetracycline	16	32	62.3	53.07 - 70.91					36.9	0.8				17.2	41.8	3.3		
Erythromycin	>16	>16	67.2	58.13 - 75.44				32.8					0.8	9.0	57.4			
Azithromycin	>16	>16	67.2	58.13 - 75.44				32.8					6.6	8.2	52.5			
Ciprofloxacin	16	16	64.8	55.56 - 73.22					32.0	1.6	1.6	1.6	9.8	43.4	9.0	0.8		
Chloramphenicol	4	64	43.4	34.49 - 52.72							27.0	27.0	2.5		18.0	24.6	0.8	

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.12.2. Distribution of MICs and resistance(%) in *Staphylococcus pseudintermedius* from cats(n=51), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution (%) of MICs													
					0.03	0.06	≦0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ampicillin	4	>16	-				7.8	7.8	9.8	3.9	15.7	9.8	19.6	9.8	15.7			
Oxacillin	2	>8	68.6	54.11-80.89			23.5	7.8	9.8	3.9	5.9	13.7	13.7	21.6				
Cefazolin	0.5	8	-				37.3	9.8	15.7	11.8	9.8	3.9	2.0	9.8				
Cefalexin	>8	>8	-							19.6	9.8	15.7	2.0	52.9				
Cefoxitin	≦1	4	-							76.5	11.8	7.8		3.9				
Cefmetazole	≦1	2	-							88.2	7.8	2.0	2.0					
Cefotaxime	1	>8	-				19.6	5.9	17.6	13.7	5.9	7.8	11.8	17.6				
Streptomycin	128	>128	-									17.6	3.9	3.9	3.9	11.8	13.7	45.1
Gentamicin	4	16	13.7	5.7-26.26					9.8	5.9	7.8	33.3	29.4	11.8	2.0			
Tetracycline	16	32	52.9	38.45-67.07					35.3		2.0	7.8	2.0	23.5	29.4			
Erythromycin	>16	>16	70.6	56.05-82.66				15.7	3.9		2.0	7.8	2.0	17.6	51.0			
Azithromycin	16	>16	66.7	52.07-79.25				19.6		2.0	5.9	5.9	11.8	13.7	41.2			
Ciprofloxacin	16	32	88.2	76.13-95.56					3.9		7.8	7.8	17.6	47.1	15.7			
Chloramphenicol	32	64	64.7	50.06-77.57							7.8	19.6	2.0	5.9	29.4	35.3		

White fields represent the range of dilutions tested.

MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.

MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.13.1. Distribution of MICs and resistance(%) in *Klebsiella pneumoniae* from Dogs(n=62), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs															
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Cefazolin	128.0	>128	51.6	38.56-64.51								46.8	1.6				3.2	48.4		
Cefalexin	32.0	>128	51.6	38.56-64.52							1.6	33.9	8.1	4.8	1.6	6.5	1.6	41.9		
Cefotaxime	2.0	64.0	48.4	35.49-61.44					48.4		3.2	4.8	1.6	9.7	8.1	16.1	8.1			
Meropenem	≦0.25	≦0.25	0.0	0-5.78				95.2	4.8											
Streptomycin	≦4	>128	29.0	18.19-41.95								61.3	4.8	4.8		1.6	11.3	16.1		
Gentamicin	≦2	64.0	29.0	18.19-41.95							66.1	4.8		4.8	11.3	6.5	6.5			
Kanamycin	≦4	32.0	8.1	2.67-17.83								62.9	11.3	11.3	6.5	1.6	1.6	4.8		
Tetracycline	≦2	＞64	37.1	25.16-50.31							51.6	8.1	3.2	1.6	1.6	4.8	29.0			
Nalidixic acid	128.0	>128	54.8	41.68-67.52								35.5	1.6	8.1		3.2	1.6	50.0		
Ciprofloxacin	2.0	＞8	48.4	35.49-61.44	17.7	16.1		3.2	8.1	3.2	3.2	1.6	46.8							
Colistin	≦8	≦8	0.0	0-5.78					96.8	3.2										
Chloramphenicol	≦4	>128	27.4	16.85-40.24								50.0	17.7	4.8	4.8	6.5	3.2	12.9		

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs					
					≦9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	19/1	>152/8	46.8	33.98-59.89	45.2	6.5	1.6	1.6	1.6	43.5

White fields represent the range of dilutions tested.
MIC values equal to or lower than the lowest concentration tested are presented as the lowest concentration.
MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

Table 12.13.2. Distribution of MICs and resistance(%) in *Klebsiella pneumoniae* from cats(n=24), in 2017

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs															
					0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Cefazolin	>128	>128	87.5	67.63-97.35								12.5						87.5		
Cefalexin	>128	>128	87.5	67.63-97.36							4.2	8.3				4.2		83.3		
Cefotaxime	64.0	>64	87.5	67.63-97.35					12.5				8.3	8.3	25.0	37.5	8.3			
Meropenem	≦0.25	≦0.25	0.0	0-14.25				95.8	4.2											
Streptomycin	64.0	>128	58.3	36.64-77.9								25.0	12.5	4.2	4.2	12.5	16.7	25.0		
Gentamicin	64.0	>64	62.5	40.59-81.21							37.5			8.3	16.7	20.8	16.7			
Kanamycin	16.0	>128	25.0	9.77-46.72								33.3	12.5	25.0	4.2	4.2	4.2	16.7		
Tetracycline	64.0	>64	58.3	36.64-77.9							29.2	8.3	4.2			16.7	41.7			
Nalidixic acid	>128	>128	87.5	67.63-97.35								8.3	4.2					87.5		
Ciprofloxacin	＞4	＞4	87.5	67.63-97.35	4.2	4.2			4.2			8.3	79.2							
Colistin	≦0.5	≦0.5	4.2	0.1-21.13					95.8					4.2	0.0					
Chloramphenicol	8.0	>128	25.0	9.77-46.72								29.2	33.3	12.5	8.3	0.0	4.2	12.5		

Antimicrobial agent	MIC_{50}	MIC_{90}	%Resistant	95% Confidence interval	Distribution(%) of MICs					
					≦9.5/0.5	19/1	38/2	76/4	152/8	>152/8
Sulfamethoxazole /Trimethoprim	>152/8	>152/8	83.3	61.99-95.76	16.7					83.3

White fields represent the range of dilutions tested.
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MIC values greater than the highest concentration in the range are presented as one dilution step above the range.

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