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FINRES-Vet 2018

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

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Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

fimea
Finnish Medicines Agency

UNIVERSITY OF HELSINKI
FACULTY OF VETERINARY MEDICINE

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Abstract

Consumption of veterinary antimicrobials in food-producing animal species in Finland is low and in recent years, has decreased further. Drop is noted in sales of almost all antimicrobial classes. Particularly sales of orally administered products have decreased. Sales of tablets intended to companion animals has almost halved during this decade. Majority, two thirds, of all antimicrobial products sold in 2018 was for treatment of individual animals and the remaining third products applicable for group treatment. Narrow spectrum penicillin G was the most used antimicrobial for animals and the proportion of highest priority critically important antimicrobials (HPCIA) was very low.

The antimicrobial resistance situation in bacteria from animals and food has remained relatively good in Finland. However, in certain bacteria resistance was detected in moderate or high levels. Therefore, there is a need to further emphasise the preventive measures and prudent use of antimicrobials. It is important to follow the Finnish recommendations for the use of antimicrobials in animals.

Among salmonella and campylobacter isolated from Finnish food-producing animals, resistance levels were mainly low. For the first time in Finland, multidrug resistant *S.* Kentucky was isolated from cattle in 2018. From 2014, the occurrence of fluoroquinolone and tetracycline resistance in campylobacter from broilers have varied. The occurrence of fluoroquinolone resistance in indicator *E. coli* has increased although the resistance is still low. Among pathogenic bacteria isolated from food-producing animals the most notifiable change was the worsening of resistance in some bovine respiratory disease pathogens. In other pathogens from food-producing animals the resistance situation remained similar as in previous years.

The proportion of resistant bacterial isolates from companion animals and horses decreased for nearly all antimicrobials. However, the proportion of resistant isolates is still high for some antimicrobials.

ESBL/AmpC-producing bacteria were still encountered in broilers and broiler meat; prevalence of these bacteria in broiler meat was somewhat lower in 2018 compared to 2016.

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Tiivistelmä

Tuotantoeläinten mikrobilääkkeiden myynti Suomessa on vähäistä ja viime vuosina se on vähentynyt edelleen. Myynti on laskenut lähes kaikissa lääkeryhmissä. Varsinkin suun kautta annettavia valmisteita myytiin aikaisempaa vähemmän. Seuraeläinten tablettien myynti on lähes puolittunut tällä vuosikymmenellä. Valtaosa, kaksi kolmannesta, vuonna 2018 myydyistä eläinten mikrobilääkkeistä oli tarkoitettu yksilölääkintään ja loppukolmannes eläinryhmien hoitoon. Kapeakirjoinen penisilliini oli eläinten käytetyin mikrobilääkeaine ja ihmisten lääkinnässä kriittisen tärkeiden mikrobilääkkeiden (HPCIA) osuus oli erittäin vähäinen.

Eläimistä ja elintarvikkeista eristettyjen bakteerien mikrobilääkeresistenssitilanne Suomessa on edelleen suhteellisen hyvä. Joillakin bakteereilla resistenssiä kuitenkin esiintyy kohtalaisesti tai yleisesti, joten eläinten mikrobilääkkeiden käyttötarpeen vähentämiseen ja hallittuun mikrobilääkkeiden käyttöön tulee edelleen kiinnittää huomiota. Eläimille annettuja mikrobilääkkeiden käyttösuosituksia on syytä noudattaa.

Kotimaisista tuotantoeläimistä eristetyillä salmonelloilla ja broilereista eristetyillä kampylobakteereilla resistenssiä todettiin pääasiassa vähän. Vuonna 2018 suomalaisilta naudoilta todettiin ensimmäisen kerran useassa muussakin Euroopan maassa esiintyvä moniresistentti *Salmonella* Kentucky. Vuodesta 2014 alkaen broilereista eristetyillä kampylobakteereilla on todettu vaihtelevasti resistenssiä fluorokinoloneille ja tetrasykliinille. Myös broilereista eristetyillä *E. coli* -indikaattoribakteereilla fluorokinoloniresistenssin esiintyminen on lisääntynyt, vaikka resistenssi on vielä vähäistä. Tuotantoeläimille tautia-aiheuttavien patogeenien resistenssitilanteen kannalta merkittävin muutos aiempiin vuosiin verrattuna oli joidenkin nautojen hengitystiepatogeenien resistenssitilanteen huonontuminen. Muuten tuotantoeläinten patogeenien resistenssitilanteessa ei todettu merkittäviä muutoksia.

Seura- ja harrastuseläimistä eristettyjen bakteerien joukossa resistenssi väheni seurantajakson aikana lähes kaikkien mikrobilääkkeiden suhteen. Tietyille mikrobilääkkeille resistenttien kantojen osuus on kuitenkin vielä korkea.

ESBL/AmpC-bakteereita esiintyi edelleen broilereilla ja broilerinlihassa; esiintyvyys broilerinlihassa oli hieman alhaisempi vuonna 2018 vuoteen 2016 verrattuna.

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Försäljningen av antimikrobiella läkemedel för produktionsdjur i Finland är låg och har minskat ytterligare under de senaste åren. Försäljningen har minskat i nästan alla läkemedelsgrupper. I synnerhet preparat som administreras oralt såldes mindre än tidigare. Försäljningen av tabletter för sällskapsdjur har minskat med nästan hälften under detta decennium. Största delen, två av tre antimikrobiella läkemedel för djur som såldes år 2018 var avsedda för medicinering av individer och en tredjedel för behandling av djurgrupper. Det mest använda antimikrobiella medlet som användes för djur var penicillin med smalt spektrum, och andelen antimikrobiella läkemedel (HPCIA) som är kritiskt viktiga i humanmedicin var mycket låg.

Resistenssituationen hos bakterier som har isolerats från djur och livsmedel av animaliskt ursprung har hållits relativt god i Finland. Hos vissa bakterier var förekomsten av resistens ändå måttlig eller vanlig. Därför måste uppmärksamhet ägnas åt att minska behovet av att använda antimikrobiella medel för djur och kontrollerad användning av antimikrobiella medel. Det är viktigt att följa rekommendationerna för användning av antimikrobiella medel för djur.

Hos salmonellabakterier som isolerats från inhemska livsmedelsproducerande djur och campylobakterier som isolerats från broilrar påvisades huvudsakligen endast litet resistens. År 2018 påvisades den multiresistenta *Salmonella* Kentucky för första gången hos finländska kor. Den förekommer även i flera andra länder i Europa. Sedan 2014 har varierande resistens mot fluorokinoloner och tetracykliner påvisats hos campylobakterier som isolerats från broilrar. Förekomsten av resistens mot fluorokinoloner hos *E. coli* -indikatorbakterier som isolerats från broilrar har också ökat även om resistens var ändå mattlig. Bland patogener isolerade från livsmedelsproducerande djur mest anmärkningsvärd ändring har skett i patogener från lunginflammation hos kalvar där resistens-situation har försämrats. Annars konstaterades inga särskilda förändringar.

Hos bakteriestammar som isolerats från hundar, katter och hästar minskade resistensen för så gott som alla antibiotika. För vissa läkemedel är andelen resistenta stammar trots allt fortfarande hög.

ESBL/AmpC-bakterier förekom fortfarande hos broilrar och i broilerkött; förekomsten i broilerkött var något lägre år 2018 jämfört med år 2016.

CONTENTS

Introduction

The occurrence of antimicrobial resistance in bacteria from animals in Finland has been screened already in the 1980's starting with salmonella isolates from food-producing animals. The regular annual antimicrobial resistance monitoring programme, FINRES-Vet, started in 2002 and includes resistance surveillance of zoonotic and indicator bacteria as well as of certain animal pathogens. Currently, resistance is monitored as required by the Commission Implementing Decision 2013/652/EU and as decided at the national level.

Resistance monitoring of zoonotic bacteria is of uttermost importance as they can be transmitted between animals and humans, creating a direct threat to human health. Also, monitoring the resistance situation in animal pathogens is vital for revealing putative emerging resistance traits as well as indicating the effectiveness of antimicrobial treatment in veterinary medicine. However, it must be emphasized that when assessing the overall resistance levels of pathogenic bacteria isolated from clinical cases, data may be biased because the isolates are frequently obtained from severe or recurrent infections.

The resistance of indicator bacteria in a given population reflects the selection pressure caused by the use of antimicrobials. The indicator bacteria constitute the major component of intestinal microbiota and their genomes can also function as a reservoir for resistance genes, which may be transferred to pathogenic bacteria.

FINRES-Vet programme has the following objectives:

- to monitor the consumption of antimicrobial agents used in veterinary medicine,
- to monitor the resistance to antimicrobial agents in bacteria from the major food-producing animals, food and pets,
- to analyse trends in the occurrence of resistant bacteria from animals and food,
- to monitor the emergence of resistant clones and the appearance of new resistance phenotypes in bacteria from the afore-mentioned sources.

The previous FINRES-Vet reports have presented an overall favorable resistance situation among bacteria isolated from animals and food of animal origin in Finland. This is probably the positive outcome of the strict policy; antimicrobial drugs for treating animals are prescribed only by veterinarians and no profit can be made from their sales. However, the increase in the occurrence of multidrug resistant bacteria in food-producing animals and the resistance in some animal pathogens is of growing concern indicating that there is a need to further emphasise the preventive measures and prudent use of antimicrobials for animals. Recommendations for antimicrobial usage in the major infectious diseases of animals have been established to promote prudent use. These recommendations have been updated in 2016 and can be found in the internet site of Finnish Food Authority (ruokavirasto.fi or foodauthority.fi).

This eighth FINRES-Vet report includes new monitoring data from the year 2018. Also, data from previous years have been included to aid in interpreting trends in the occurrence of resistance. The report covers resistance results of indicator bacteria (non-pathogenic *E. coli* from poultry), zoonotic bacteria (salmonella from food-producing animals and campylobacter from poultry), and several animal pathogens from the main food-producing animal species (pigs, cattle, poultry), fur animals, companion animals (dogs, cats) and horses. In addition, the results of the specific monitoring of extended-spectrum beta-lactamase producing *E. coli* from poultry and poultry meat is included.

The FINRES-Vet programme is coordinated and the antimicrobial resistance in bacteria from food-producing animals is monitored by the Finnish Food Authority Ruokavirasto (former Evira). The sales of antimicrobial agents for veterinary use is monitored by Finnish Medicines Agency Fimea, and the use of feed additives and medicated feeds by Ruokavirasto. The Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine (University of Helsinki) provides antimicrobial susceptibility data from companion animals and horses.

1 Use of therapeutic antimicrobials and feed additives for animals in Finland

1.1 Changes in animal population

Changes in the number of food-producing animals from 2017 to 2018 were relatively small. The decreasing trend in the number of pigs continued; 8% from 2017 to 2018. A slow annual increase in the number of poultry is also seen (Figure 1). Details on the number of holdings, live animals, and meat and milk production are presented in Appendix 1. The number of livestock and the number of animals slaughtered is used to calculate animal population, which is described using Population Correction Unit (PCU). Since 2010, the PCU has decreased from 520 to 500 (thousand tons). PCU of pigs has decreased the most. At the same time PCU of poultry has increased steadily.

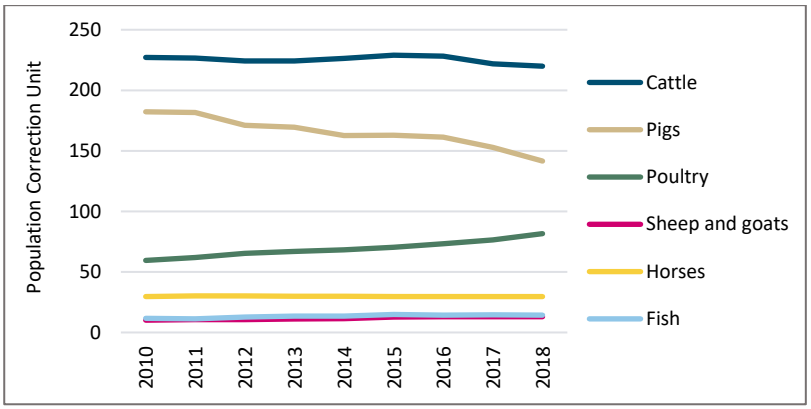

Figure 1. *Changes in food-producing animal populations in Finland in 2010-2018, expressed in PCU. Detailed data on the PCU of food-producing animals in a tabulated form is presented in Appendix 1.*

Regarding the number of companion animals, Statistics Finland estimated that the number of dogs and cats in 2012 was 630 000 and 592 000, respectively. In 2016, the number of dogs had been estimated to have increased slightly to 700 000 while the number of cats remained stable.

1.2 Therapeutic antimicrobials

1.2.1 Background

Finnish medicines agency Fimea monitors the sales of veterinary antimicrobials based on statistics obtained from pharmaceutical wholesalers. Sales data reported as kilograms of active ingredient is available since 1995. This report includes data for 2010-2018, for a review of data for 1995-2009 see the FINRES-Vet reports covering the corresponding years.

In 2010, sales data collection of veterinary antimicrobials in Finland was harmonised with the protocol of European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project (EMA, 2019). Data covers also veterinary antimicrobials sold with special licence (exemption from marketing authorisation, i.e.

veterinary antimicrobial products obtained from another Member State and permitted to be marketed for specific animal species). As a deviation from the ESVAC-protocol, human medicinal products sold with special licence for use in animals are included although their sales are very low.

Sales data are presented as kilograms of active ingredient for overall sales and sales by different administration routes i.e. injectables, orally administered antimicrobials and intramammaries. For intramammaries also sales of tubes per cow is reported.

In order to compare changes in annual sales of antimicrobials, the data is linked to the number of animals. To estimate the numbers of food-producing animals, a population correction unit (PCU) is used. PCU is strictly a technical unit which corresponds approximately to one kg and gives an estimate of livestock and slaughtered animals in a given year. PCU has been developed within the ESVAC project and a detailed description of PCU calculation is available in 'Trends in the sales of veterinary antimicrobial agents in nine European countries: Reporting period 2005-2009' (EMA, 2011).

PCU-adjusted sales, reported as mg active ingredient per PCU, are in this report presented for the EU-indicators of veterinary antimicrobial consumption i.e. overall sales, sales of fluoroquinolones and 3rd generation cephalosporins (ECDC, EFSA and EMA, 2017). Note that PCU-corrected data does not include tablets, as they are almost exclusively used in companion animals. As only estimates of the population of dogs and cats in Finland are available, sales of tablets cannot be adjusted to the population of companion animals, and therefore, sales of tablets are presented in a separate figure, as kg active ingredient.

1.2.2 Overall sales (kg active ingredient)

Total sales of veterinary antimicrobials show a decreasing trend from 2010 (Figure 2). In 2018, the total sales were 10 157 kg which is almost a quarter less than five years earlier. Sales have decreased in almost all antimicrobial classes and particularly in orally administered products.

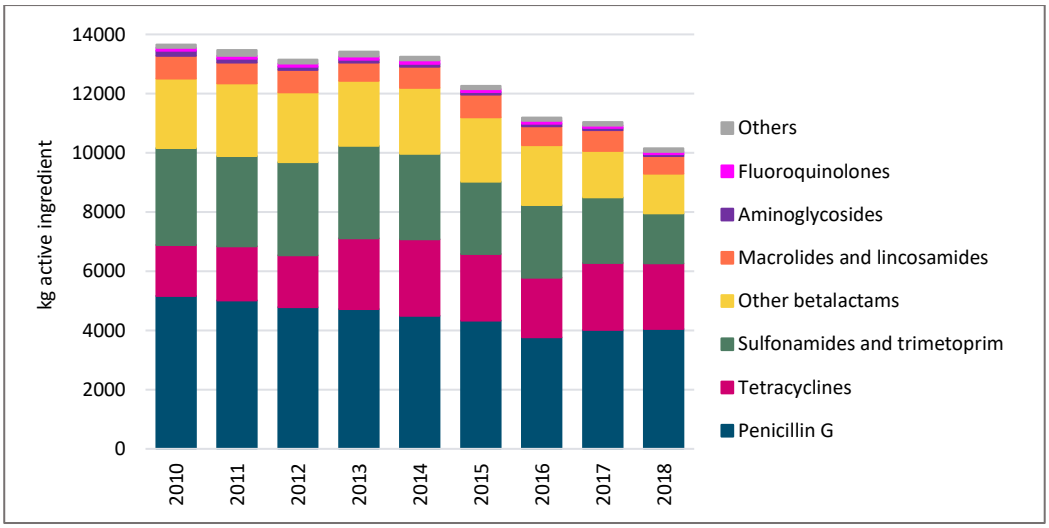

***Figure 2**. Overall sales (kg active ingredient) by class. Other betalactams = aminopenicillins, cephalosporins and cloxacillin. Others = pleuromutilines and amphenicol. Detailed data in a tabulated form is presented in Appendix 2.*

Two thirds of all antimicrobial products sold in 2018 were for treatment of individual animals (injectables, tablets, oral pastes and intramammaries) and the remaining third were products applicable for group treatment (premixes, oral powders and oral solutions) (Figure 3).

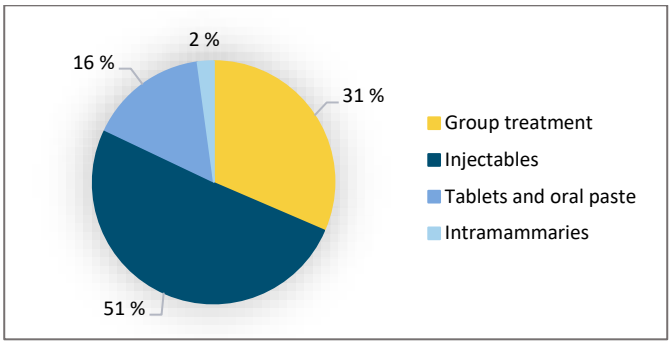

***Figure 3**. Proportioned sales of veterinary antimicrobials by form in 2018. Group treatment= premixes, oral solutions and oral powders.*

Benzylpenicillin was the most sold antimicrobial with 40% of the overall sales followed by tetracyclines (22%) and the combination of sulfonamides and trimethoprim (17%) (Figure 2.). Three antimicrobial groups of the WHO list of highest priority critically important antimicrobial classes in human medicine (HPCIA) are authorised for use in animals in Finland. These are macrolides, fluoroquinolones and 3rd generation cephalosporins. The proportion of sales for these remained low to extremely low (macrolides 4%, fluoroquinolones 0.8% and 3rd generation cephalosporins 0.005%).

1.2.3 Sales based on route of administration (kg active ingredient)

Over half of the antimicrobials sold were products administered as injections to animals (Figure 3). Benzylpenicillin remained the most sold injectable with a 74% proportion of all injectables despite a 10% decrease in sales in five years (Figure 4). Several factors have probably contributed to this change. The large-scale shortage of benzylpenicillin products in Finland in 2015-2016 caused a decrease in the sales of benzylpenicillin. An additional factor could be the continuously declining number of sows and pigs. Benzylpenicillin is also the most important antimicrobial in the treatment of lactating cows, the number of which has decreased through this decade.

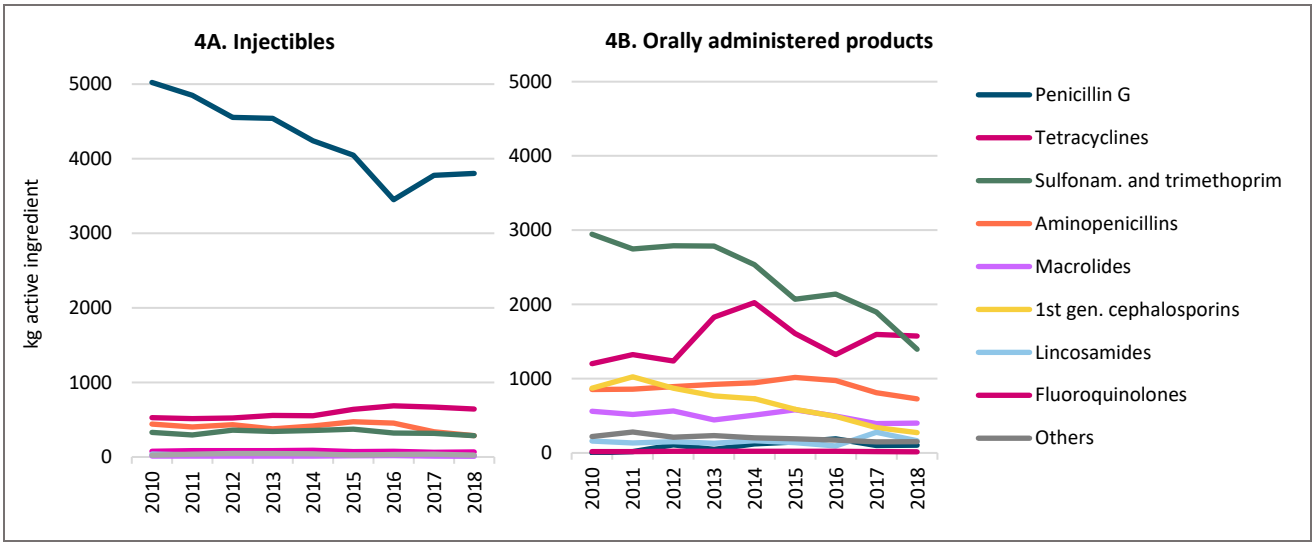

***Figure 4A and 4B**. Trends in sales of injectable veterinary antimicrobials (4A) and sales of orally administered veterinary antimicrobials (4B). Other injectables = amphenicols, aminoglycosides and cephalosporins, Other oral products = amphenicols, aminoglycosides and pleuromutilins. Detailed data in a tabulated form is presented in Appendix 2.*

Sales of orally administered products have decreased markedly in five years (Figure 4B). Reduced sales are seen for almost all antimicrobial classes, but the most notable changes were for combinations of sulfonamide and trimethoprim (-45% in five years) and for 1st generation cephalosporin (-73% since 2011).

The majority of sulfonamide and trimethoprim combinations is used for several food-producing animal species and therefore it is not possible to conclude what is causing the changes in sales from the sales data alone. By contrast the 1st generation cephalosporins are authorized solely for companion animals. Prudent use guidance has traditionally been targeted to treatment of food-producing animals but during this decade greater emphasis was placed on companion animals. As a result, the sales of veterinary antimicrobial tablets have dropped by almost half since 2011. In addition to 1st generation cephalosporins, a decreasing trend is noted for sales of aminopenicillin and fluoroquinolone tablets (Figure 5). Note that sulfonamide and trimethoprim combination tablets were withdrawn from the market in 2015 and thereafter they have been available on special licence (exemption from marketing authorisation, i.e. antimicrobial products obtained from another Member State and permitted to be marketed for specific animal species).

Detailed statistics on the number of companion animals are not available but it has been estimated that the number of dogs and cats has somewhat increased during this decade (Statistics Finland, 2016). In addition, there is no information on the number of human antimicrobials prescribed for companion animals. This data is not captured by the current data collection method, however, the amount is anticipated to be modest, as legislation requires veterinarians to prescribe veterinary medicinal products if they are available.

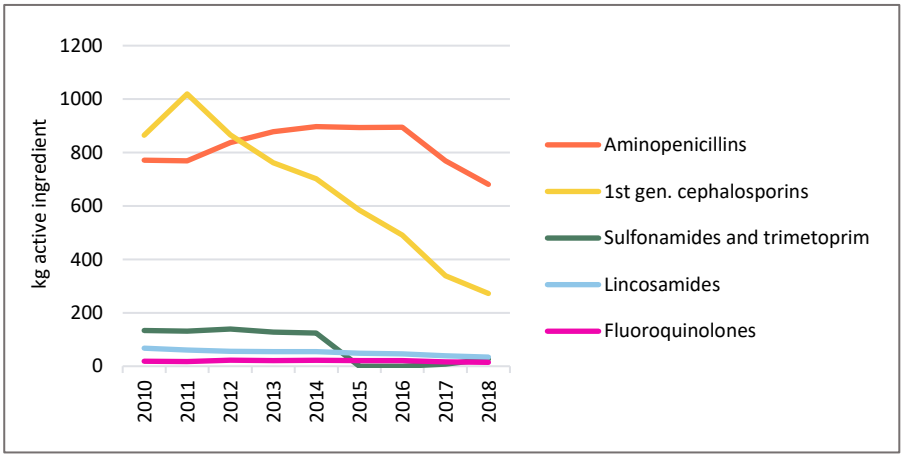

Figure 5. *Sales of antimicrobials tablets to companion animals (kg active ingredient) by class. Note that sulfonamide and trimethoprim combination tablets were withdrawn from the market in 2015.*

Sales of intramammary products for cows during lactation per cow has decreased through this decade whereas their use in dry cow therapy has somewhat increased (Figure 6).

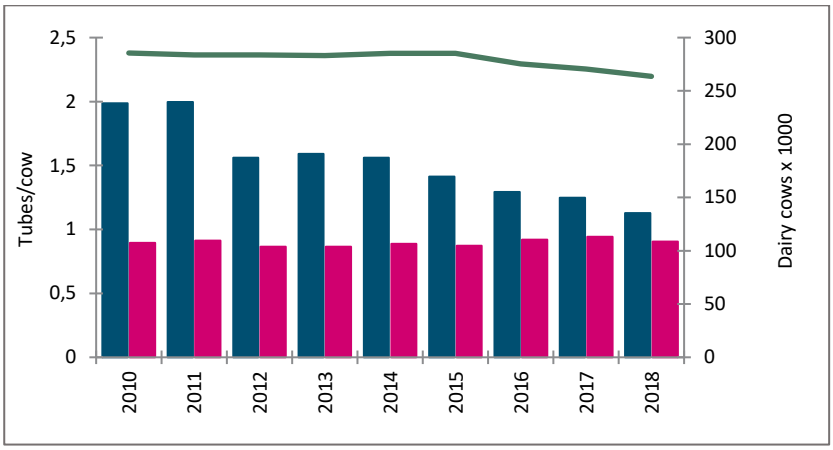

Figure 6. *Sales of antimicrobial tubes for intramammary use per cow during lactation period (blue column) and for dry cow period (red column) and the number of dairy cows (green curve).*

1.2.4 EU-indicators of antimicrobial consumption in food-producing animals (mg/PCU)

ECDC, EFSA and EMA have jointly established a list of indicators to assist EU Member States in assessing their progress in reducing the use of antimicrobials and occurrence of AMR in both humans and food-producing animals. For food-producing animals, the indicators for antimicrobial consumption are: overall sales of veterinary antimicrobials, sales of 3rd and 4th generation cephalosporins, sales of quinolones (specifying the proportion of fluoroquinolones) and sales of polymyxins, measured in mg/PCU (ECDC, EFSA ja EMA 2017). Of these, overall sales of veterinary antimicrobials, sales of 3rd generation cephalosporins and sales of fluoroquinolones measured in mg/PCU are applicable in Finland.

All EU-indicators of antimicrobial consumption in food-producing animals show similar results: the consumption of veterinary antimicrobials in food-producing animal species in Finland is very low (Table 1). In 2018 overall sales was 18 mg/PCU, representing 1 mg/PCU (6 %) decrease from 2017 and 4 mg/PCU (19 %) decrease from 2014. National legislation in force since 1949 prohibits veterinarians to profit from antimicrobial sales. The same legislation also provides that antimicrobials are prescription-only-medicines (www.ruokavirasto.fi/en/AMRmilestones). Finland also has a long history of promoting the health and welfare of food-producing animals and is free of several important animal diseases. Prudent use guidelines have been available since 1996 and have been updated three times, last in spring 2016.

Sales of 3rd generation cephalosporins have decreased significantly from an already extremely low level to close to zero (table 1). Decline since the peak year 2011 was 94%, and 9% from 2017. The major contributor to this change is presumably the control measures targeted towards those veterinarians using the highest amounts of these antimicrobials. Another factor is the prerequisite of susceptibility testing before using HPCIAs, introduced to the national law in 2014. A decreasing overall trend from 2014 is noted also for sales of fluoroquinolones.

Table 1. *EU-indicators of antimicrobial consumption in food-producing animals (mg/PCU) in Finland. Note that sales of tablets are excluded as they are used almost exclusively to companion animals.*

Sales (mg/PCU)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Overall	23	22	22	22	22	20	19	19	18
Fluoroquinolones	0.15	0.16	0.16	0.16	0.18	0.14	0.15	0.12	0.13
3rd generation cephalosporins	0.009	0.017	0.029	0.016	0.016	0.014	0.006	0.001	0.001

1.3 Coccidiostats and antimicrobial feed additives

Finnish Food Authority monitors the annual consumption of feed additives by collecting data from feed manufacturers. In Finland, the coccidiostats monensin natrium and narasin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production. In 2018, another coccidiostat, lasalocid sodium, has also been used. The overall use of coccidiostats has increased from 2005 to 2016 but has since been slightly decreasing (Table 2).

Table 2. *The use of coccidiostats, antimicrobial feed additives and other substances in feed in Finland in 2005 and 2010-2018 (kg active substance/year).*

Substance	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
Coccidiostats										
Decoquinate	0	0	0	0	0	0	0	0.1	0	0
Diclazuril	0	0	0	0	0	0	0	0	0.8	0.5
Lasalocid sodium	0	1.4	0	0	0	0	0	0	0	1336
Madmuramycin ammonium	1.5	0	0	0	0	0	0	0	0	0
Monensin natrium	[1] 8669	6801	5837	7300	4614	6677	12640	15373	14693	5097
Narasin	3204	5859	7658	6567	9626	9022	5478	5026	4918	13154
Salinomycin	[2] 374	[3] 1170	[4] 495	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0	0
Antimicrobial feed additives										
Avoparcin	0	0	0	0	0	0	0	0	0	0
Flavomycin	0	0	0	0	0	0	0	0	0	0
Carbadox	0	0	0	0	0	0	0	0	0	0
Olaquindox	0	0	0	0	0	0	0	0	0	0
Other substances										
Amprolium (and ethopabate)	0	0	0	0	0	0	0	0	0	0
Dimetridazole	0	0	0	0	0	0	0	0	0	0
Nifursol	0	0	0	0	0	0	0	0	0	0
Total	**12249**	**13832**	**13991**	**13867**	**14240**	**15699**	**18117**	**20399**	**19613**	**18587**

[1] 13.2 kg, [2] 190 kg, [3] 121 kg and [4] 58 kg used in exported feed mixtures

2 Antimicrobial resistance in zoonotic bacteria

2.1 *Salmonella enterica* in food-producing animals and domestic food

The prevalence of *Salmonella* spp. in cattle, pigs and poultry as well as in meat and eggs is monitored through the national *Salmonella* control programme (23/EEO/1995; 20/EEO/2001, 1172/2009, 1173/2009). The objective of the programme is to maintain the annual incidence of salmonella contamination among food-producing animals and in the respective meat and eggs at 1% or below. As a results, salmonella is rare in food-producing animals and foods of animal origin in Finland. Salmonella isolates from the control programme are tested for antimicrobial susceptibility and included in the FINRES-Vet programme. Isolates from clinical cases and domestic food industry's in-house control systems are also included. Details of the susceptibility testing as well as correspondences between the verbal descriptions of the resistance levels and the actual percentage categories are described in Appendix 3.

In 2018, 43 *Salmonella enterica* spp. *enterica* isolates from food-producing animals (including carcass samples) were tested for susceptibility. Most of the isolates (n=31) originated from cattle. Ten isolates originated from pigs and two isolates from *Gallus gallus*. The most common serotypes detected were *S*. Typhimurium (n=22), *S*. Enteritidis (n=6) and *S*. Kentucky (n=4). Other serotypes are shown in Appendix 4. Also, one *S*. Agama from a food sample containing bovine meat was discovered.

Resistance in salmonella from food-producing animals was overall low (Table 3). In 2018, multi-resistant *S*. Kentucky was found in one dairy farm and three calf rearing farms which had bought calves from the positive dairy farm. *S*. Kentucky isolates were resistant to ampicillin, ciprofloxacin, gentamicin, nalidixic acid, sulfamethoxazole and tetracycline. This was the first time multi-resistant *S*. Kentucky was found among food-producing animals in Finland. Multidrug resistance in salmonella isolated from Finnish food-producing animals has overall been very rare (Figure 7).

Table 3. *Distribution of MICs for Salmonella enterica in food-producing animals in 2018 (n=43).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	9.3	3.7-21.6							65.1	25.6						9.3				
Azithromycin	ND	-									67.4	30.2	2.3							
Cefotaxime	0	0.0-8.2					100													
Ceftazidime	0	0.0-8.2						86.0	14.0											
Chloramphenicol	0	0.0-8.2										100								
Ciprofloxacin	9.3	3.7-21.6	39.5	48.8	2.3							4.7	4.7							
Colistin	2.3	0.4-12.1							79.1	18.6	2.3									
Gentamicin	9.3	3.7-21.6						76.7	14.0				7.0	2.3						
Meropenem	0	0.0-8.2																		
Nalidixic acid	9.3	3.7-21.6									88.4	2.3					9.3			
Sulfamethoxazole	9.3	3.7-21.6										2.3	55.8	27.9	4.7					9.3
Tetracycline	9.3	3.7-21.6								90.7						9.3				
Tigecycline	ND	-					81.4	18.6												
Trimethoprim	0	0.0-8.2					83.7	14.0	2.3											

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration. ND, not determined

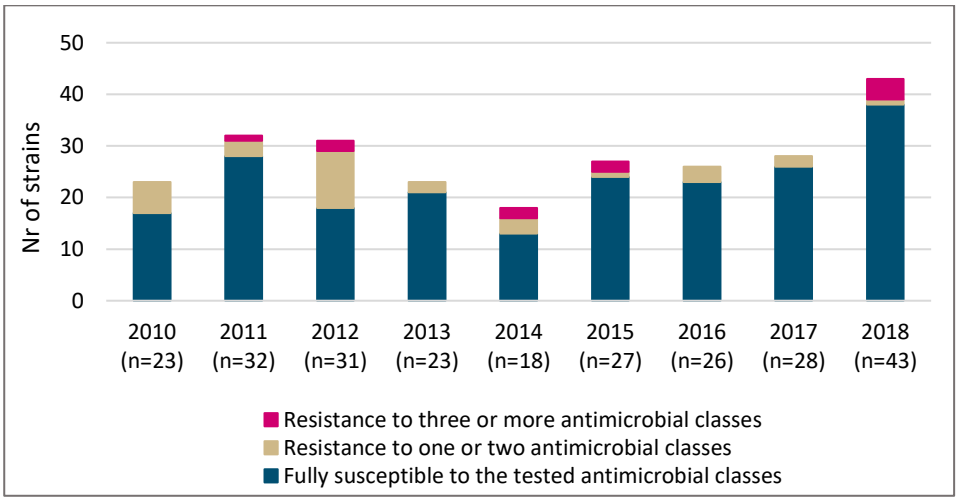

***Figure 7**. The number of sensitive and resistant salmonella isolates from food-producing animals in Finland in 2010-2018. Numbers of isolates tested each year in brackets.*

2.2 *Campylobacter* spp. in food-producing and fur animals

In 2018, *Campylobacter jejuni* isolates from broilers were obtained from the national Campylobacter control programme and *C. jejuni* from fur animals were isolated from diarrhea samples sent to the Finnish Food Safety Authority Evira.

2.2.1 *Campylobacter jejuni* from broilers

Within the national *Campylobacter* control programme in broilers, 55 *C. jejuni* isolates were tested for susceptibility in 2018. Of these, 14 (25%) were resistant to quinolones (ciprofloxacin, nalidixic acid) but resistance to the other studied antimicrobials was not detected (Table 4).

***Table 4.** Distribution of MICs for Campylobacter jejuni from broilers in 2018 (n=55).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)											
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	25.5	15.8-38.3		5.5	1.8				16.4	9.1				
Erythromycin	0	0.0-6.5				96.4	3.6							
Gentamicin	0	0.0-6.5		32.7	65.5	1.8								
Nalidixic acid	25.5	15.8-38.3					5.5	60	9.1				25.5	
Streptomycin	0	0.0-6.5		1.8	12.7	56.4	27.3	1.8						
Tetracycline	0	0.0-6.5			100									

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Antimicrobial resistance in *Campylobacter jejuni* from broilers at slaughter has been monitored systematically since 2003. Resistance levels in *C. jejuni* have been quite stable until the year 2013 and the occurrence of resistant isolates has been mainly at a low level (Figure 8). However, quinolone-resistant isolates have been more commonly detected since the year 2013. Between 2014 and 2018, the occurrence of quinolone resistance has been more common every other year with the previous high peak (25%) observed in 2014 and a smaller peak (8%) in 2016. The number of tetracycline resistant isolates peaked also in the same years and they were commonly also quinolone-resistant. However, in 2018, tetracycline resistance was not observed. The proportion of isolates resistant to erythromycin, gentamicin or streptomycin has remained

low or non-existent throughout the surveillance period. Further, the percentage of isolates susceptible to all studied antimicrobials has varied between 75%-100%, with the lowest percentage in 2014 and 2018 co-incidencing the highest occurrence of quinolone resistance (Figure 9). Multidrug resistant isolates to the tested antimicrobials have not been detected.

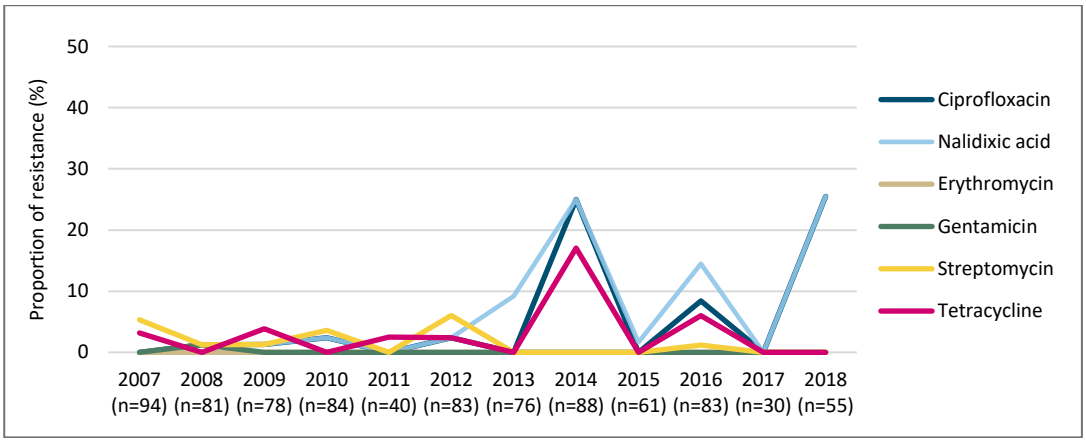

Figure 8*. The proportions of resistant Campylobacter jejuni isolates from broilers at slaughter in Finland between the years 2007 and 2018. Numbers of isolates tested each year in brackets.*

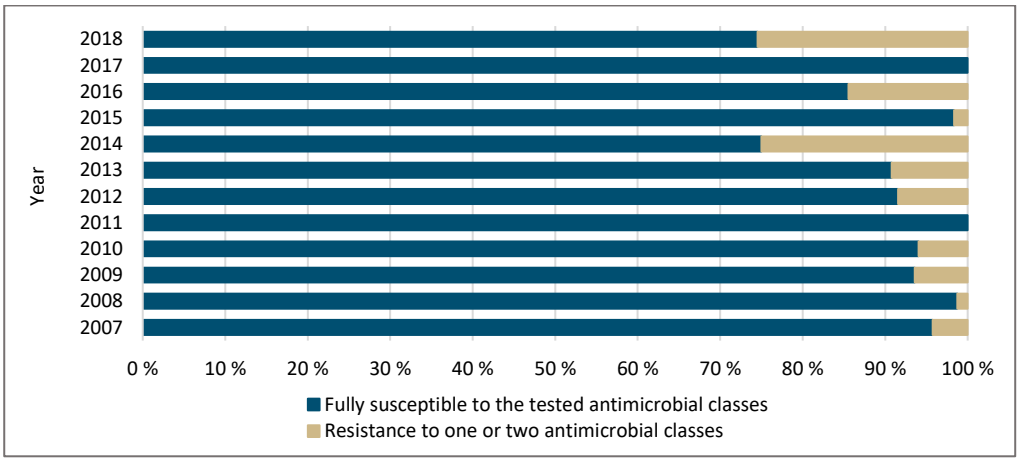

Figure 9. *Antimicrobial susceptibility of Campylobacter jejuni isolated from broilers at slaughter in Finland between the years 2007 and 2018. Numbers of isolates tested each year are the same as in Figure 8.*

2.2.2 *Campylobacter jejuni* from fur animals

Campylobacter spp. are isolated from fur animals as part of diarrhea examination. *Campylobacter jejuni* infections in fur animals are treated with antimicrobials and these bacteria pose also a risk to the farmers. Isolates are mostly from farmed fox and to a lesser extent from mink.

In 2018, the occurrence of resistance was moderate against quinolones and low against tetracycline and streptomycin (Table 5). Compared to year 2016, resistance to ciprofloxacin has decreased almost 4 percentage points, and resistance to tetracycline about 30 percentage points.

Table 5. *Distribution of MICs for Campylobacter jejuni from fur animals in 2018 (n=62).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)											
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	12.9	6.7-23.4	85.5	1.6				1.6	9.7	1.6				
Erythromycin	0.0	0.0-5.8				100								
Gentamicin	0.0	0.0-5.8		37.1	53.1	4.8								
Nalidixic acid	12.9	6.7-23.4					8.1	62.9	16.1			1.6	11.3	
Streptomycin	1.6	0.3-8.6		1.6	6.5	64.5	24.2	1.6		1.6				
Tetracycline	8.1	3.5-17.5			91.9					3.2	1.6	3.2		

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

3 Screening for ESBL-, AmpC- and carbapenemase-producing *Escherichia coli* from food-producing animals and meat

Screening of extended-spectrum beta-lactamase producing *E. coli* from food-producing animals and meat thereof is part of the harmonised monitoring in all EU member states (Comission Decision 2013/652/EU). In Finland, these bacteria are screened from broilers, cattle and pigs, as well as meat thereof, targeting broilers and broiler meat in 2018. Additionally, liners from the transport boxes of imported broiler and turkey parental flocks for meat production as well as of imported chicken parental flocks for egg production are screened annually. The details of the methodology are described in Appendix 3.

3.1 ESBL/AmpC- and carbapenemase-producing *E. coli* in broilers and broiler meat

In 2018, extended-spectrum beta-lactamase (including AmpC beta-lactamase) producing *E. coli* were screened from broiler caecal samples (n=289) collected at slaughterhouses and from broiler meat (n=300) collected at retail. From broilers, ESBL- or AmpC-producing *E. coli* was isolated from 13.1% (38/289) of the caecal samples in 2018 (Table 6). The prevalence of ESBL/AmpC-producing *E. coli* in broilers is at the same level as in 2016 and has increased compared to year 2014 when these bacteria were isolated from 7% of the samples, however using somewhat different method (different enrichment broth) for isolation (FINRES-Vet 2013-2015). Details of the methodology is described in Appendix 3.

All screened broiler meat samples have been of domestic origin, fresh and without added ingredients. In 2018, ESBL- or AmpC-producing *E. coli* were isolated from 15.3% (46/300) of the samples (Table 6), which is approximately 7 percentage points less than in 2016. No carbapenemase-producing *E. coli* was detected in broilers or broiler meat.

Table 6. *Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing E. coli in broilers and broiler meat in 2016 and 2018.*

Year	Source	Sampling stage	Nr of samples	Nr (%) of ESBL[1]	Nr (%) of AmpC[1]	Nr of CP-EC[2]	% ESBL/AmpC
2016	Broiler	at slaughter	306	11 (3.6%)[3]	33 (11.1%)	0	14.4%
2018	Broiler	at slaughter	289	5 (1.7%)	33 (11.4%)	0	13.1%
2016	Broiler meat	at retail	309	15 (4.9%)	53 (17.1%)[4]	0	22.0%
2018	Broiler meat	at retail	300	9 (3.0%)	37 (12.3%)	0	15.3%

[1] based on phenotypic characterization, see appendix 3.
[2] CP-EC, carbapenemase-producing Escherichia coli
[3] one isolate was resistant also to cefoxitin
[4] phenotype of one isolate was confirmed only with AmpC & ESBL ID Set (D68C, Mast Diagnostics, UK)

3.2 ESBL/AmpC- and carbapenemase-producing *E. coli* in imported poultry flocks

In 2018, liners of transport boxes of 42, five and five imported poultry flocks intended for broiler meat, turkey meat and chicken egg production chains, respectively, were screened for ESBL/AmpC- and carbapenemase-producing *E. coli* (Table 7). Positive flocks were not detected in any of the groups.

Over the prior screening period of 2013-2017, none of the tested turkey flocks have been found to harbour ESBL/AmpC-producing *E. coli* whereas 11 to 75% and 0 to 75% of the imported broiler and chicken egg

production flocks, respectively, have been positive. Carbapenemase-producing *E. coli* have not been detected. This is the first year that all the tested imported poultry flocks appear to be free also from ESBL/AmpC-producing *E. coli*.

Table 7. *Results of the specific screening of ESBL- and AmpC-producing E. coli in liners from the transport boxes of imported poultry flocks and eggs.*

Imported poultry flocks	2013	2014	2015	2016	2017	2018
For broiler meat production						
Nr of sampled flocks	4	37	54	62	37	42
Nr of ESBL positive flocks	2	1	1	0	0	0
Nr of AmpC positive flocks	2	3	9	24	8	0
Nr (%) of ESBL/AmpC positive floks	3 (75 %)	4 (11 %)	10 (19 %)	24 (39 %)	8 (22 %)	0 (0 %)
For turkey production						
Nr of sampled flocks	5	5	6	5	4	5
Nr of ESBL positive flocks	0	0	0	0	0	0
Nr of AmpC positive flocks	0	0	0	0	0	0
Nr (%) of ESBL/AmpC positive floks	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)
For egg production						
Nr of sampled flocks	3	6	4	3	4	5
Nr of ESBL positive flocks	0	1	1	0	0	0
Nr of AmpC positive flocks	1	3	2	0	3	0
Nr (%) of ESBL/AmpC positive floks	1 (33 %)	4 (67 %)	3 (75 %)	0 (0 %)	3 (75 %)	0 (0 %)

4 Antimicrobial resistance in animal pathogens from food-producing animals

Animal pathogens isolated from food-producing animals in this report include *Escherichia coli* from porcine enteritis, *Staphylococcus aureus* from broiler arthritis and tenosynovitis, *E. coli* from colibacillosis in broilers, bovine respiratory pathogens *Pasteurella multocida, Mannheimia haemolytica* and *Histophilus somni*, swine respiratory pathogen *Actinobacillus pleuropneumoniae*, and *Brachyspira pilosicoli* from pigs. CLSI clinical breakpoints are used when available. Details of sampling, isolation procedures and susceptibility testing are described in Appendix 3.

4.1 *Escherichia coli* from pig enteritis

Escherichia coli isolates from pig enteritis cases were obtained from faecal or postmortem samples submitted to Evira. All isolates were confirmed by PCR to be enterotoxigenic. Altogether, 88 *E. coli* isolates from 34 farms were included. However, the results are not representative of the whole Finnish pig enteritis *E. coli* population due to the low number of isolates and the fact that at least part of the isolates are likely to originate from farms with diarrheal problems and higher than average antimicrobial usage.

The MIC distributions and the resistance percentages using epidemiological cut-off values are given in Table 8. As before, resistance was commonly detected against ampicillin, fluoroquinolones, tetracycline, streptomycin, sulfamethoxazole and trimethoprim. Resistance against 3rd generation cephalosporins was detected in five isolates from three farms, all phenotypically AmpC. No ESBL-producers were detected. Resistance to florfenicol and chloramphenicol was low. No resistance was detected against colistin or gentamicin in 2016, 2017 or 2018.

Table 8. *Distribution of MICs for Escherichia coli from porcine enteritis in 2018 (n=88). Resistance percentage (%R) is the proportion of resistant isolates calculated using epidemiological cut-off values.*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	35.2	26.1-45.6							20.5	38.6	4.5	1.1		6.8	1.1		27.3			
Cefotaxime	4.5	1.8-11.1			17.0	63.6	14.8	4.5												
Ceftazidime	5.7	2.5-12.6					62.5	31.8	5.7											
Chloramphenicol	9.1	4.7-16.9								13.6	64.8	9.1	3.4	4.5	4.5					
Ciprofloxacin	27.3	19.1-37.4	5.6	61.4	5.7	20.5	4.5			2.3										
Colistin	0.0	0.0-4.2						69.3	26.1	4.5										
Enrofloxacin	11.4	6.3-19.7			69.3	19.3	8.0	1.1			2.3									
Florfenicol	1.1	0.2-6.2									53.4	43.2	2.3	1.1						
Gentamicin	0.0	0.0-4.2						78.4	19.3	2.3										
Nalidixic acid	21.6	14.3-31.3								55.7	15.9	4.5	2.3	10.2	5.7	5.7				
Streptomycin	31.8	22.0-41.0									43.2	19.3	5.7	4.5	9.1	18.2				
Sulfamethoxazole	35.2	26.1-45.6										45.5	17.0	2.3					1.1	34.1
Tetracycline	27.2	19.1-37.4							63.6	8.0	1.1			6.8	4.5	10.2	5.7			
Trimethoprim	29.5	21.3-39.8				22.7	29.5	11.4	4.5	2.3				29.5						
Trim/sulfa[1]	26.1	18.1-36.2						73.9				26.1								

Bold vertical lines indicate epidemiological cut-off values for resistance. Dotted vertical lines indicate clinical breakpoints for susceptibility (left dotted vertical line) and resistance (right dotted vertical line). Clinical breakpoints are given only if they are available and differ from the epidemiological cut-off values. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

[1] Concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20

Between 2016 and 2018, no dramatic changes can be seen in resistance levels to the tested antimicrobials (Figures 9 and 10) using epidemiological cut-off values. As in previous years, multidrug resistance (resistance to ≥3 antimicrobial classes) was commonly detected. The proportions of multidrug resistant isolates and isolates fully susceptibility to the tested antimicrobials have been relatively similar during the last three years (Figure 9).

Clinical resistance was also commonly detected to all antimicrobial classes that can be used to treat *E. coli* infections in pigs (sulfonamide-trimethoprim, tetracycline, aminopenicillins, fluoroquinolones). When the clinical breakpoints were applied, 36 isolates (41%) from 18 farms (52%) were multidrug resistant in 2018. Note that for fluoroquinolones (enrofloxacin), interpretation of resistance using clinical breakpoints differs the most compared to the epidemiological cut-off values (Table 8).

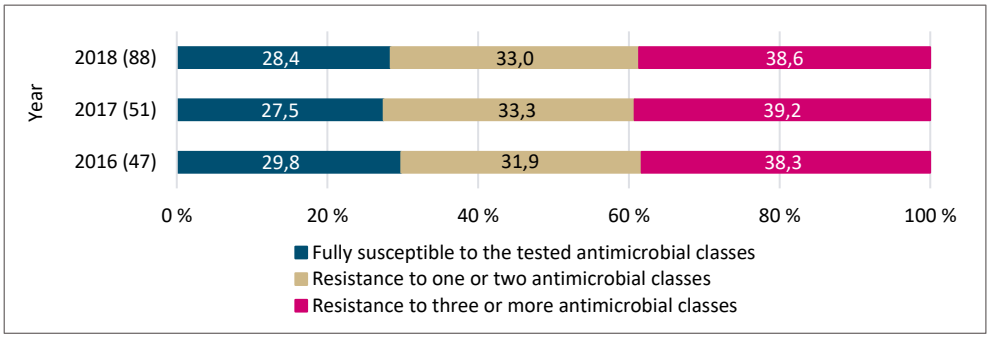

***Figure 9**. The proportions of multidrug resistant E. coli isolates from porcine enteritis in years 2016-2018 using epidemiological cut-off values. Numbers of isolates tested each year in brackets.*

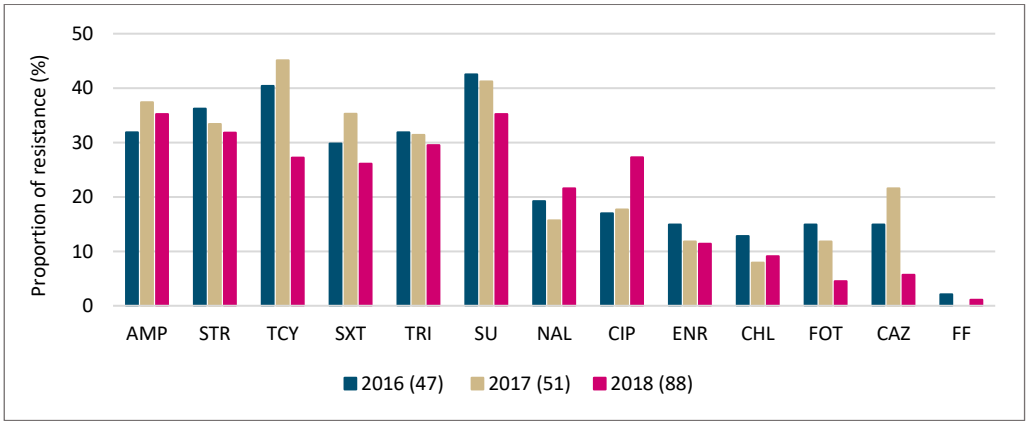

***Figure 10**. Proportion of resistance to the tested antimicrobials in Escherichia coli from porcine enteritis between 2016 and 2018 using epidemiological cut-off values. Number of isolates tested each year in brackets.*
AMP, ampicillin; STR, streptomycin, TCY, tetracycline; SXT, trimethoprim-sulfamethoxazole; TRI, trimethoprim, SU, sulfamethoxazole; NAL, nalidixic acid; CIP, ciprofloxacin; ENR; enrofloxacin; CHL, chloramphenicol; FOT, cefotaxime; CAZ, ceftazidime; FF, florfenicol

4.2 *Actinobacillus pleuropneumoniae* from swine respiratory disease

A. pleuropneumoniae is the most important respiratory pathogen in growing pigs in Finland. In 2018, altogether 32 isolates from 25 farms were tested for antimicrobial susceptibility. All obtained isolates were included. As in previous years, intermediate susceptibility against oxytetracycline was common (Table 9). No resistance against tiamulin, tulathromycin, florfenicol or ceftiofur was detected. Between 2016 and 2018, no

significant changes in the MICs for the tested substances can be seen. However, the number of tested isolates each year is rather small.

Table 9. *Distribution of MICs for Actinobacillus pleuropneumoniae from pigs in 2018 (n=32).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Florfenicol	0.0	0.0-10.7		96.9	3.1								
Ceftiofur	0.0	0.0-10.7		100									
Penicillin[1]	0.0	0.0-10.7	40.6	37.5	21.9								
Oxytetracycline	0.0	0.0-10.7			84.4	15.6							
Tiamulin	0.0	0.0-10.7				3.1			46.9	50.0			
Tulathromycin	0.0	0.0-10.7						3.1	9.4	40.6	46.9		

Bold vertical lines indicate clinical breakpoints for susceptibility (left vertical line) and resistance (right vertical line). Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.
[1] clinical breakpoint not available

4.3 *Brachyspira pilosicoli* from pigs

There are no standardised breakpoints established for *Brachyspira pilosicoli* from pigs. As a guide for the choice of antimicrobial for treatment of spirochaetal diarrhoea, a clinical breakpoint for tiamulin of >1 mg/L, for tylosin of >2 mg/L, for valnemulin of >1 mg/L and for lincomycin of >4 mg/L are used in Finland. With these breakpoints, 65% of the isolates were resistant to tylosin and 15% to lincomycin (Table 10). No resistance against tiamulin and valnemulin was detected. Resistance in *B. pilosicoli* has been at the same level 2015-2018, although the number of isolates tested each year are too small to draw any definite conclusions.

Table 10. *Distribution of MICs for Brachyspira pilosicoli from pigs in 2018 (n=20).*

Substance	Distribution (%) of MICs (mg/L)													
	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline			25.0	55.0		5.0	15.0							
Lincomycin					70.0	10.0	5.0			10.0	5.0			
Tiamulin		70.0	15.0	10.0	5.0									
Tylosin							35.0	40.0	10.0				5.0	10.0
Tylvalosin					25.0	30.0	25.0	10.0			5.0	5.0		
Valnemulin	70.0	5.0	20.0	5.0										

No clinical breakpoints available. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

4.4 *Histophilus somni*, *Pasteurella multocida* and *Mannheimia haemolytica* from bovine respiratory disease

During 2018, the number of farms sending samples for respiratory disease diagnostics dropped compared to the two previous years. One isolate per submission (and from each compartment if more than one was sampled) and per bacterial species was selected for susceptibility testing. *H. somni* isolates were obtained from 28 farms and 93% (26/28) of these had only isolates fully susceptible to the tested antimicrobials. *H. somni* isolates resistant or intermediate to oxytetracycline was detected and originated from two farms.

Pasteurella multocida isolates were obtained from 124 farms and 96% (199/124) of them had fully susceptible isolates. Decreased susceptibility to oxytetracycline was the most common resistance trait although detected at low level. *Mannheimia haemolytica* isolates were obtained from 44 farms and 81%

(39/44) of them had fully susceptible isolates. The proportion of *M. haemolytica* isolates resistant oxytetracycline continued to increase, as well as the proportion of isolates with decreased sensitivity to penicillin.

Table 11. *Distribution of MICs for Histophilus somni from bovine respiratory disease in 2018 (n=30).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	0.0	0.0-11.4		100									
Enrofloxacin	0.0	0.0-11.4	100										
Florfenicol	0.0	0.0-11.4		100									
Oxytetracycline	3.3	0.6-16.7			90.0		3.3	3.3		3.3			
Penicillin	0.0	0.0-11.4	90.0	10.0									
Tulathromycin	0.0	0.0-11.4				10.0	30.0	40.0	20.0				

Bold vertical lines indicate clinical breakpoints for susceptibility (left vertical line) and resistance (right vertical line). Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Table 12. *Distribution of MICs for Pasteurella multocida from bovine respiratory disease in 2018 (n=186).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	0.0	0.0-2.0		98.9	1.1								
Enrofloxacin	0.0	0.0-2.0	99.5		0.5								
Florfenicol	0.0	0.0-2.0		74.2	25.3	0.5							
Oxytetracycline	3.2	1.5-6.9			78.5	8.6	9.1	0.5		3.2			
Penicillin	0.0	0.0-2.0	98.4	1.1	0.5								
Tulathromycin	0.5	0.1-3.0				39.2	41.9	16.7		1.6			0.5

Bold vertical lines indicate clinical breakpoints for susceptibility (left vertical line) and resistance (right vertical line). Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

Table 13. *Distribution of MICs for Mannheimia haemolytica from bovine respiratory disease in 2018 (n=49).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	0.0	0.0-7.4		97.9	2.1								
Enrofloxacin	0.0	0.0-7.4	97.9	2.1									
Florfenicol	0.0	0.0-7.4			81.3	18.7							
Oxytetracycline	4.2	1.2-14.0			95.8					4.2			
Penicillin	12.5	5.9-24.7	45.8	25	16.7	8.3				4.2			
Tulathromycin	0.0	0.0-7.4					14.6	85.4					

Bold vertical lines indicate clinical breakpoints for susceptibility (left vertical line) and resistance (right vertical line). Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

4.5 *Escherichia coli* from colibacillosis and other infections in broilers

Since 2014, colibasillosis has been a major problem in broiler production in Nordic countries including Finland. In 2017, a vaccination program with an autogen vaccine against two major serotypes was started in some broiler chains and the colibacillosis situation appears to be slightly better in 2018. Colibacillosis infections in broilers or broiler parents are not treated with antimicrobials in Finland. Most of the samples are obtained from parent flocks. Based on epidemiological cut-off values, resistance was less common in 2018 than in previous years and was detected only against tetracycline and trimethoprim (Table 14). Only single isolates resistant to 3rd generation cephalosporins were found in 2016 and 2017 (FINRES-Vet 2016-2017) but not at all in 2018. The occurence of resistance to different antimicrobials has varied annually which is probably due to the small number of tested isolates.

Table 14. *Distribution of MICs for Escherichia coli from colibacillosis in 2018 (n=19)*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	0.0	0.0-16.8							15.8	68.4	10.5	5.3								
Cefotaxime[1]	0.0	0.0-16.8			29.4	70.6														
Ceftazidime[1]	0.0	0.0-16.8					82.4	17.6												
Ciprofloxacin	0.0	0.0-16.8		89.5	10.5															
Colistin[1]	0.0	0.0-16.8						82.4	17.6											
Sulfamethoxazole	0.0	0.0-16.8										84.2	10.5	5.3						
Tetracycline	10.6	2.9-31.4							63.2	26.3				5.3	5.3					
Trimethoprim	5.3	0.9-24.6					47.4	42.1		5.3				5.3						

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.
[1] n=17

4.6 *Staphylococcus aureus* from tenosynovitis in broilers

Staphylococcus aureus from broiler tenosynovitis cases were isolated from clinical and post-mortem samples submitted to Evira. All obtained *S. aureus* isolates were included. Twenty-one isolates from 13 farms were studied. All isolates were susceptible to the reported antimicrobials (Table 15). No isolates were found to produce beta-lactamase and no MRSA isolates were found. Tenosynovitis is occasionally treated with antimicrobials in broiler parent flocks but annually only a small number of flocks are treated. Production flocks have not been treated with antimicrobials since 2010 (Animal Health ETT ry. https://www.ett.fi/wp-content/uploads/2019/09/Use-of-antibiotics-in-poultry-meat-production-in-Finland-2007-2018.pdf).

Table 15. *Distribution of MICs for Staphylococcus aureus from tenosynovitis in broilers in 2018 (n=21).*

Substance	%R	95%C.I.	Distribution (%) of MICs (mg/L)											
			0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64
Cefoxitin	0.0	0.0-15.5							14.3	85.7				
Penicillin[1]	0.0	0.0-15.5	81.0	14.3	4.8									
Tetracycline	0.0	0.0-15.5					100							
Trim/sulfa[2]	0.0	0.0-15.5			100									

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.
[1] resistance profiles based on beta-lactamase production
[2] concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20

5 Antimicrobial resistance in animal pathogens from companion animals and horses

Antimicrobial resistance figures from companion animal pathogens (dogs, cats and horses) were collected from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. In this context antimicrobial resistance corresponds to the proportion of resistant and intermediate isolates. The reporting period covers January 2014 – December 2018 and includes solely bacterial isolates derived from clinical infections. Approximately 36% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 64% from private veterinary clinics. If the number of tested bacterial isolates for the bacterial species in question was large enough, data are presented separately for dogs, cats and horses. Otherwise, collated data are presented. Details of the susceptibility testing method are described in Appendix 3.

5.1 *Staphylococcus aureus* from companion animals and horses

The material included 331 *S. aureus* isolates (42 – 107 isolates per year) from dogs, cats and horses. Antimicrobial resistance in this pathogen was low to very low (Figure 11), except for penicillin. Beta-lactamase results were available for 271 isolates (2014-2018), of which 67% were positive. Beta-lactamase production was more common in canine *S. aureus* isolates (79%, 136/172) than in equine isolates (19%, 8/43) ($p<0.0001$, *Chi*-square test), while there was no statistical difference in beta-lactamase production between canine and feline (68%, 38/56) *S. aureus* isolates ($p=0.86$, *Chi*-square test).

Oxacillin resistance (indicating the presence of MRSA) was generally at a low level, ranging from 0 – 9%, being 6.3% in 2018. Of the six MRSA isolates detected in 2018, five were from specimens submitted by different private clinics. Four isolates were from dogs and two others from a cat and a horse.

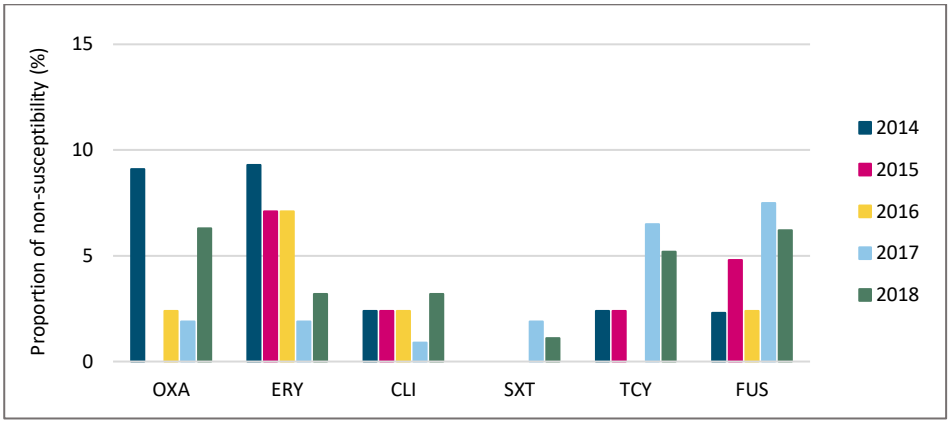

Figure 11. *Antimicrobial non-susceptibility (%) in Staphylococcus aureus from dogs, cats and horses in 2014-2018. The number of tested isolates per year: 44 (2014), 42 (2015), 42 (2016), 107 (2017) and 96 (2018).*
OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline; FUS, fucidic acid.

5.2 *Staphylococcus pseudintermedius* from dogs

Antimicrobial resistance remained at a relatively high level in *Staphylococcus pseudintermedius* for erythromycin and clindamycin in 2018, despite the slightly decreasing tendency during the previous years. Decreasing resistance levels for tetracycline (as well as for doxycycline) and fucidic acid were noted during the whole period. Sulfonamide-trimethoprim resistance remained stable – around 10-12% – during the whole period (Figure 12).

The proportion of MRSP isolates, as indicated by oxacillin non-susceptibility, was moderate (12-14%) in 2014-2016, but then decreased to 9% in 2017, and further down to 6% in 2018 (Figure 12). Chloramphenicol resistance remained stable, between 14 and 19%, during the whole period, but non-susceptibility to enrofloxacin decreased (from 7% to 3% during the whole period) (Figure 13).

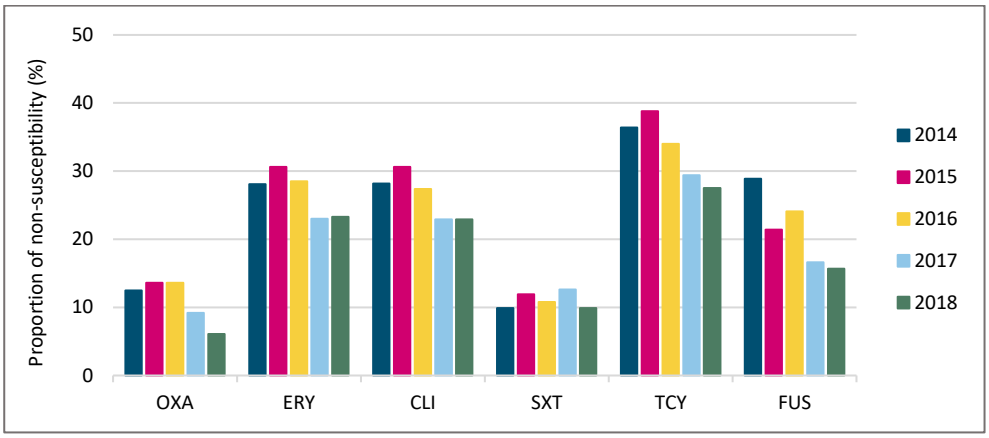

***Figure 12**. Antimicrobial non-susceptibility (%) in canine Staphylococcus pseudintermedius isolates in Finland in 2014-2018 for primary antimicrobial agents. Number of tested isolates per year: 401 (2014), 396 (2015), 477 (2016), 749 (2017), 936 (2018). For each antimicrobial, there can be small variations from these numbers.*
OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline; FUS, fucidic acid

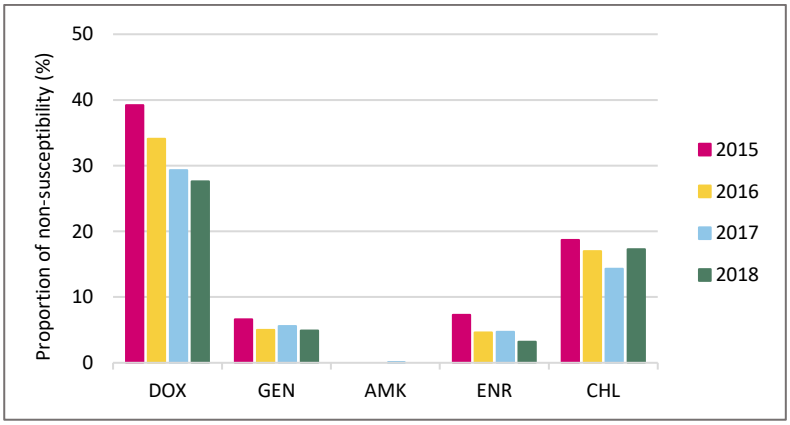

***Figure 13**. Antimicrobial non-susceptibility (%) in canine Staphylococcus pseudintermedius isolates in Finland in 2015-2018 for secondary antimicrobial agents. Number of tested isolates per year: 396 (2015), 477 (2016), 749 (2017), 936 (2018). For each antimicrobial, there can be some variations from these numbers.*
DOX, doxycycline; GEN, gentamicin; AMK, amikacin; ENR, enrofloxacin; CHL, chloramphenicol

5.3 *Escherichia coli* from dogs and cats

Altogether, 1837 canine and 334 feline *Escherichia coli* isolates were tested during the years 2014-2017, but in 2018 alone there where 1041 canine and 187 feline isolates (in total 2878 canine and 521 feline isolates in 2014-2018). Resistance figures for canine and feline *E. coli* are presented in Figure 14 and 15, respectively. In general, feline *E. coli* isolates were more susceptible to antimicrobials than canine isolates, although they were more resistant in 2018 than in the previous years.

Ampicillin non-susceptibility was similar in both canine and feline *E. coli* isolates in 2018 (37% vs. 35%, respectively). However, in canine isolates, the proportion of ampicillin non-susceptible strains was significantly lower ($p<0.00001$, Chi-square test) in 2018 (37%) than in 2017 (50%). Feline *E. coli* isolates had a greater proportion of resistance to ampicillin in 2018 when compared to 2017 (35% vs. 27%), but the difference was not statistically significant ($p=0.08$, Chi-square test). In canine *E. coli*, the resistance to amoxicillin-clavulanic acid continued to decrease. In 2018, the proportion of non-susceptible strains was 11%, when in 2017 the corresponding figure was 16%.

Enrofloxacin resistance in canine *E. coli* isolates decreased during the last four years, being less than 7% in 2018. Sulfonamide-trimethoprim resistance in canine and feline *E. coli* fluctuated through the monitoring period, having been 13% in dogs and 7% in cats in 2018.

In 2018, 5.3% of canine *E. coli* were resistant to cefpodoxime indicating reduced susceptibility to third generation cephalosporins, with a downward drift from 2016 to 2018 (Figure 16). The proportion of ESBL-producing isolates continued to decrease, being 1.2% in 2018, but the proportion of AmpC-producing isolates remained quite stable compared to 2017 (3.7% in 2018). Less than 3% of feline *E. coli* isolates had either ESBL or AmpC phenotype.

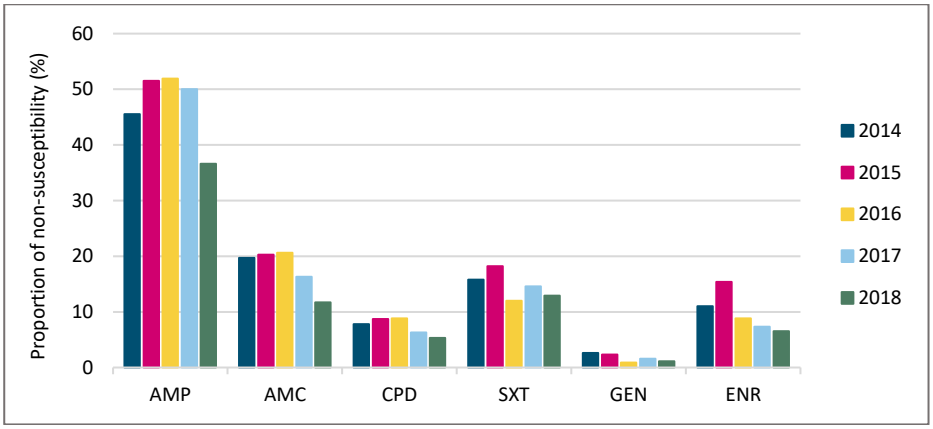

***Figure 14**. Antimicrobial non-susceptibility (%) in canine E. coli in Finland in 2014-2018. Number of tested isolates: 310 (2014), 390 (2015), 457 (2016), 680 (2017), 1041 (2018).*
AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; SXT, trimethoprim-sulfamethoxazole; GEN, gentamicin; ENR, enrofloxacin

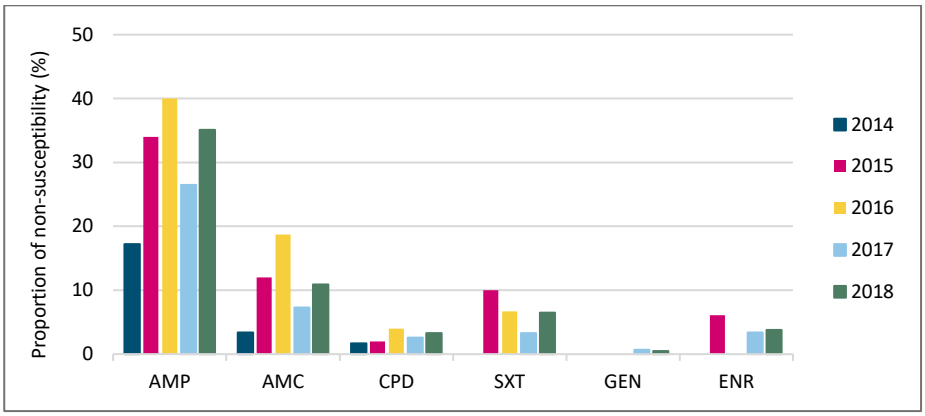

***Figure 15**. Antimicrobial non-susceptibility (%) in feline E. coli in Finland in 2014-2018. Number of tested isolates: 58 (2014), 50 (2015), 75 (2016), 151 (2017), 187 (2018).*
AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; SXT, trimethoprim-sulfamethoxazole; GEN, gentamicin; ENR, enrofloxacin

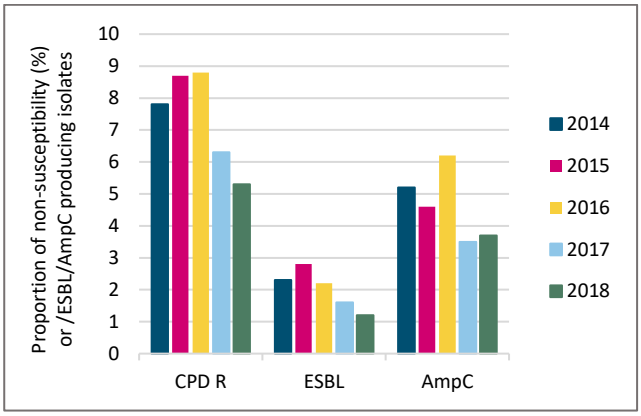

***Figure 16.** Proportion of isolates with reduced susceptibility to cefpodoxime (CPD), and proportion of ESBL and AmpC positive isolates in canine E. coli, 2014-2018.*
CPD, cefpodoxime

5.4 Streptococci from dogs and horses

All *Streptococcus canis* isolates from dogs were susceptible to penicillin and nearly all to sulfamethoxazole-trimethoprim (Figure 17). Erythromycin and clindamycin resistance rates remained stable: in 2018, 8% and 11% of isolates showed resistance to these antimicrobials, respectively. Tetracycline resistance was at a high level although a decreasing tendency was observed.

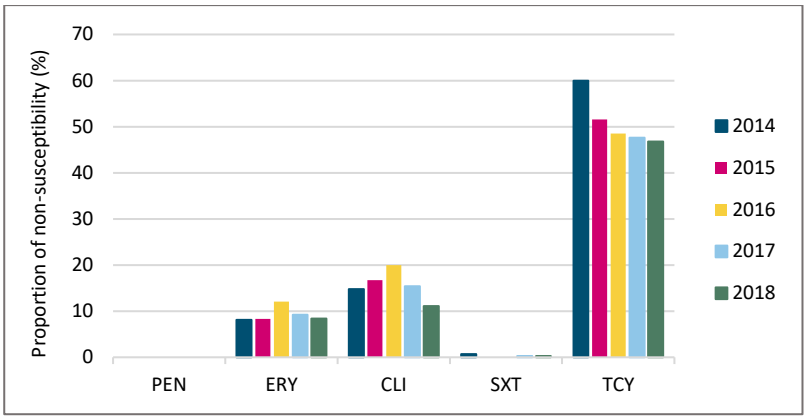

***Figure 17**. Antimicrobial resistance (%) in canine S. canis isolates in Finland in 2014-2018. Number of tested strains: 135 (2014), 157 (2015), 207 (2016), 293 (2017), 392 (2018).*
PEN, penicillin; ERY, erythromycin, CLI, clindamycin, SXT, trimethoprim-sulfamethoxazole, TCY, tetracycline

During the period of 2014-2018, 174 *Streptococcus equi* ssp. *zooepidemicus* isolates were tested. All of the isolates were susceptible to penicillin. For sulfamethoxazole-trimethoprim, the increasing trend in the proportion of resistant strains did not continue after 2017: in 2018, 7% (3/47) of the strains expressed resistance, while the corresponding proportion in 2017 was 12% (4/47). The development of this resistance still has to be monitored carefully due to the importance of this drug in the treatment of many equine infections.

5.5 *Pseudomonas aeruginosa* from dogs

In 2018, 105 isolates of canine *Pseudomonas aeruginosa* were tested. Overall, the strains were quite susceptible to all tested antimicrobials. Three percent of the strains expressed amikacin resistance, and 4% were non-susceptible to gentamicin. No resistance to polymyxin B or tobramycin was detected. Most isolates (88%) were susceptible to ciprofloxacin. As expected, the opposite was true for enrofloxacin because majority of the isolates (64%) showed intermediate susceptibility for this antimicrobial even though they were susceptible to ciprofloxacin. Approximately 18% of the isolates were resistant to enrofloxacin. However, since enrofloxacin is metabolized to ciprofloxacin *in-vivo*, resistance testing with current breakpoints may overestimate the non-susceptibility, especially because in many cases infections caused by *P. aeruginosa* are treated with locally administered antimicrobials.

6 Antimicrobial resistance in indicator bacteria from food-producing animals

Resistance in the commensal gram-negative indicator *E. coli* is a reflection of the most common resistance traits among the gram-negative bacteria present in the gut microbiota, the selection pressure caused by the antimicrobials used in the animal population. In this report, resistance of the indicator *E. coli* from slaughtered broilers are presented. Details of the sampling and laboratory analysis are described in Appendix 3.

6.1 Indicator *E. coli* from broilers

In 2018, a total of 173 isolates from broilers were tested for antimicrobial susceptibility to 14 antimicrobials. The majority of the isolates was fully susceptible to the tested antimicrobial classes. The most common resistance traits detected were against ampicillin (13%), tetracycline (6%), ciprofloxacin (6%) sulfamethoxazole (6%) and trimethoprim (5%) (Table 18). The number of resistant isolates against tetracycline continued to decrease while the proportion of resistant isolates against the other aforementioned antimicrobials increased from the year 2016 (Figure 16).

Further, 5% of the isolates were multiresistant and their proportion has almost doubled from 2014 (Figure 17, data from the years prior to 2014 are not included as they are not completely comparable because partly different antimicrobials were included in the susceptibility testing). The most commonly detected resistance profiles in the multiresistant isolates in 2018 were resistance against ampicillin, sulfamethoxazole, ciprofloxacin and nalidixic acid, and against ampicillin, tetracycline, sulfamethoxazole and trimethoprim (Table 19). Also, as in 2016, one AmpC isolate was detected.

Table 18. *Distribution of MICs for indicator Escherichia coli in broilers in 2018 (n=173).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	13.3	9.0-19.2							0.6	30.6	52.6	2.9				13.3				
Azithromycin	ND	-								2.3	66.5	30.6	0.6							
Cefotaxime	0.6	0.1-3.2					99.4					0.6								
Ceftazidime	0.6	0.1-3.2						99.4					0.6							
Chloramphenicol	0.6	0.1-3.2										97.1	2.3			0.6				
Ciprofloxacin	5.8	3.2-10.3	81.5	12.7		0.6	3.5	0.6				1.2								
Colistin	0	0.0-2.2							100											
Gentamicin	1.2	0.3-4.1						32.4	60.1	6.4				1.2						
Meropenem	0	0.0-2.2		100																
Nalidixic acid	5.8	3.2-10.3									93.1	1.2			0.6	2.3	2.9			
Sulfamethoxazole	6.4	3.6-11.0										75.1	17.9	0.6						6.4
Tetracycline	6.4	3.6-11.0								85.5	7.5	0.6		0.6	1.7	4.0				
Tigecycline	0	0.0-2.2					93.1	6.9												
Trimethoprim	5.2	2.8-9.6					56.1	36.4	1.7	0.6					5.2					

Bold vertical lines indicate epidemiological cut-off values for resistance. Hatched fields denote range of dilutions tested for each substance. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration. ND, not determined

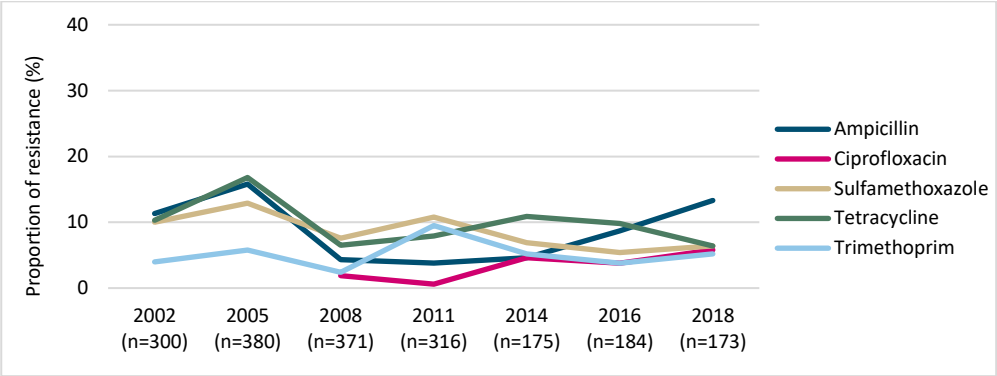

***Figure 16**. Resistance in indicator E. coli from broilers to selected antimicrobials in 2002-2018. In brackets the number of isolates tested each year.*

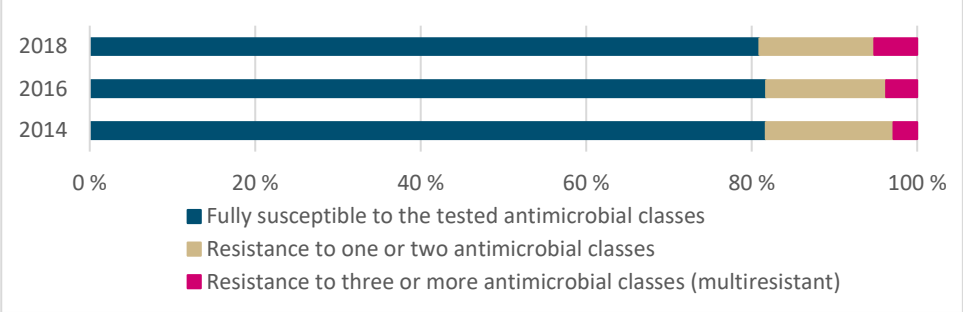

***Figure 17**. Antimicrobial susceptibility of indicator E. coli from broilers at slaughter in Finland between the years 2014 and 2018. Numbers of the isolates tested each year are the same as in Figure 16.*

***Table 19**. Detected resistance profiles among indicator E. coli from broilers in 2014, 2016 and 2018.*

Resistance profile	Nr of isolates in each year		
	2014	2016	2018
AMP-SU-TRI	0	0	**1**
AMP-SU-CIP-NAL	0	**1**	**3**
AMP-TET-SU-TRI	0	**1**	**3**
AMP-TET-SU-TRI-CIP-NAL	0	0	**1**
AMP-SU-TRI-CIP-NAL	0	**1**	0
AMP-CAZ-CIP-FOT-NAL-SU-TET-TRI	0	**1***	0
TET-SU-TRI	**5**	**3**	0
TET-SU-TRI-CIP-NAL-GEN-CHL	0	0	**1**
AMP-CAZ-FOT	0	0	1*
AMP-CIP	0	1	0
AMP-CIP-NAL	2	0	1
AMP-TET	5	3	4
AMP-SU	1	0	1
AMP-TRI	0	1	1
CIP-NAL	5	2	4
CIP-NAL-SU	0	1	0
CIP-NAL-TRI	1	0	0
GEN-SU	0	0	1
SU-TRI	2	0	0
SU-TET	4	2	0
AMP	0	7	7
GEN	1	0	0
TET	5	8	2
TRI	1	0	2
Susceptible	143	152	140

Abbreviations: AMP, Ampicillin; CAZ, ceftazidime; CHL, chloramphenicol; CIP, ciprofloxacin; FOT, cefotaxime; GEN, gentamicin; NAL, nalidixic acid; SU, sulfamethoxazole; TET, tetracycline; TRI, trimethoprim.
Multiresistant phenotypes are bolded; *Phenotypically AmpC

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EMA > Veterinary regulatory > Overview > Antimicrobial resistance > Analysis of antimicrobial consumption and resistance ('JIACRA' reports) > Outcome indicators
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Appendix 1. Population statistics

The population of food-producing animals (as PCU) is presented in Table 20. The number of livestock and farms, and the production of meat and milk in Finland are presented in Tables 21-24 (Source: Luke, the Natural Resources Institute Finland).

***Table 20**. Population of food-producing animals as PCU (1000 tonnes) in 2010-2018.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cattle	227,06	226,64	224,27	224,33	226,22	228,97	228,06	221,73	219,91
Pigs	182,22	181,63	171,19	169,61	162,55	162,98	161,26	152,79	141,57
Poultry	59,51	61,82	65,30	66,91	68,32	70,25	73,32	76,37	81,62
Sheep and goats	10,17	10,59	10,65	11,10	11,38	12,83	13,00	12,97	13,02
Horses	29,72	30,20	30,16	30,00	29,84	29,68	29,68	29,76	29,76
Fish	11,772	11,275	12,659	13,613	13,465	14,877	14,413	14,587	14,324

***Table 21.** Number of livestock (in thousands) in Finland in 2010-2018.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dairy cows	289	286	284	283	285	285	282	275	271
Suckler cows	55	57	58	57	58	59	59	60	60
Cattle > 1 year[1]	278	273	268	271	268	264	258	261	252
Calves < 1 year	303	299	303	300	303	307	310	297	299
TOTAL, Cattle	926	914	913	912	914	915	909	893	882
Boars and sows	154	146	136	128	123	NA[2]	NA	NA	NA
Pigs > 20 kg	804	797	779	815	760	NA	NA	NA	NA
Piglets < 20 kg	409	392	375	365	362	NA	NA	NA	NA
TOTAL, pigs	1367	1335	1290	1308	1245	1243	1235	1136	1089
Laying hens	3394	3304	3173	3432	3645	3595	3599	3746	3985
Chicks	838	745	743	858	714	662	748	509	608
Broilers	4616	5421	6038	6861	7341	7827	8272	8047	8781
Turkeys	280	308	295	274	292	246	260	292	299
Other poultry[2]	459	457	512	555	584	597	566	543	468
TOTAL, poultry	9587	10236	10761	11981	12577	12927	13445	13136	14140

[1] Heifers and bulls in total
[2] Including broilerhens
Number of cattle on 1.5. Number of pigs and poultry 1.4.
Number of poultry in 2016 not totally comparable with the previous years.
Source: OFS: Luke, Number of livestock.

***Table 22.** Number of farms in Finland in 2010-2018.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cattle farms total	15641	14919	14141	13416	12885	12389	11791	11175	10530
Pig farms total	2078	1917	1747	1637	1486	1337	1240	1102	1027
Poultry farms total	1304	1314	1155	1207	1299	1310	1300	1280	1243

Source: OFS: Luke, Number of livestock, http://stat.luke.fi/en/number-of-livestock.

***Table 23**. The production of meat and fish (million kg) in Finland in 2010-2018.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beef[1]	82	83	80	80	82	86	86	85	86
Pork[1]	203	202	193	194	186	192	190	182	169
Poultry[1]	96	102	107	111	113	117	125	129	135
Total	383	387	382	387	383	397	403	397	391
Fish[2]	12	11	13	14	13	15	14	15	14

[1] In slaughterhouses; [2] for human consumption, ungutted
Source: OFS: Luke, Meat production, http://stat.luke.fi/en/meat-production and Aquaculture, http://stat.luke.fi/en/aquaculture.

Table 24. *The production of milk in Finland in 2010-2018.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Milk production; per animal (litres)	7896	7859	7876	7977	8201	8323	8406	8534	8650
Total milk production (million litres)	2268	2234	2230	2260	2330	2365	2359	2336	2328

Source: OFS: Luke, Milk and milkproducts statistics, http://stat.luke.fi/en/milk-and-milk-product-statistics.

Appendix 2. Sales of antimicrobials for animals, kg active ingredient

Table 25. *Overall sales of veterinary antimicrobials in Finland 2010-2018, kg active ingredient.*

	2010	2011	2012	2013	2014	2015	2016	2017[1]	2018
Tetracyclines	1728	1838	1759	2389	2576	2250	2010	2268	2218
Amphenicols	59	124	61	121	84	80	87	104	112
Penicillin G	5162	5010	4784	4721	4502	4332	3773	4018	4055
Aminopenicillins	1317	1284	1342	1314	1374	1498	1438	1160	1020
Cloxacillin	114	112	97	82	91	65	63	45	39
1st gen. cephalosporins	906	1056	902	793	753	605	513	355	284
3rd gen. cephalosporins	5	9	15	8	8	7	3	1	0,5
Sulfonamides and trimethoprim[1]	3274	3045	3149	3129	2893	2445	2460	2216	1682
Macrolides	572	532	575	456	521	596	517	408	411
Lincosamides	202	164	179	155	189	165	120	297	184
Aminoglycosides	166	128	108	103	101	93	87	73	61
Fluoroquinolones	96	102	107	105	113	94	99	80	81
Pleuromutilins	48	73	66	43	44	30	23	14	10
Total sales	**13651**	**13475**	**13144**	**13419**	**13250**	**12262**	**11192**	**11037**	**10157**

[1] Sales of sulfonamides and trimethoprim in 2017 corrected

Table 26. *Sales of injectable veterinary antimicrobials in Finland 2010-2018, kg active ingredient.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tetracyclines	527	515	521	558	552	640	686	671	642
Amphenicols	0	12	13	26	17	6	13	26	15
Penicillin G	5023	4849	4552	4542	4243	4047	3450	3777	3804
Aminopenicillins	440	404	434	379	416	473	453	338	286
1st gen. cephalosporins	0	0	0	0	0	0	5	1	1
3rd gen. cephalosporins	5	9	15	8	8	7	3	1	0
Sulfonamides and trimethoprim	329	297	360	344	358	373	322	317	286
Macrolides	13	13	11	12	12	15	19	13	10
Lincosamides	40	30	27	24	26	26	25	19	18
Aminoglycosides	19	18	20	12	15	13	14	12	10
Fluoroquinolones	78	85	84	83	90	72	78	63	66
Total sales of injectables	**6472**	**6230**	**6036**	**5990**	**5737**	**5672**	**5069**	**5238**	**5139**

Table 27*. Sales of orally administered veterinary antimicrobials (premixes, oral solutions, oral powders, oral pastes and tablets) in Finland 2010-2018, kg active ingredient*

	2010	2011	2012	2013	2014	2015	2016	2017[1]	2018
Tetracyclines	1202	1323	1237	1830	2024	1610	1324	1597	1575
Amphenicols	59	112	48	95	67	74	74	78	97
Penicillin G	0	17	110	47	122	147	190	100	105
Aminopenicillins	856	860	893	923	947	1017	976	813	728
1st gen. cephalosporins	872	1025	871	766	730	587	493	341	274
Sulfonamides and trimethoprim[1]	2945	2747	2789	2784	2535	2072	2138	1899	1397
Macrolides	559	519	565	444	510	581	498	395	402
Lincosamides	161	134	152	130	164	139	94	278	165
Aminoglycosides	95	79	76	76	70	62	54	41	32
Fluoroquinolones	19	17	23	22	22	22	22	16	15
Pleuromutilines	48	73	66	43	44	30	23	14	10
Total sales of orally adm. products	**6816**	**6906**	**6829**	**7160**	**7236**	**6342**	**5885**	**5571**	**4798**

[1] Sales of sulfonamides and trimethoprim in 2017 corrected

Tables 28A and 28B. *Sales of intrammaries for veterinary use in Finland 2010-2018, kg active ingredient*

28A. Intramammaries for lactation phase

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Penicillin[1]	104	107	94	94	100	94	85	92	98
Aminopenicillins	15	14	11	8	8	7	7	6	5
Cephalexin	29	30	31	27	22	18	15	13	9
Cloxacillin	60	56	47	39	41	31	29	19	18
Aminoglycosides	29	12	1	0	0	0	0	0	0
Macrolides	1	1	0	0	0	0	0	0	0
Total sales imm. lactation phase	**237**	**220**	**185**	**168**	**170**	**150**	**136**	**129**	**129**

[1]Sales of penicillin in 2013 corrected

28B. Intramammaries for dry cow treatment

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Penicillin[1]	35	38	28	38	37	44	47	50	48
Aminopenicillins	6	6	5	4	3	2	2	3	1
Cephalexin	6	1	0	0	0	0	0	0	0
Cloxacillin	55	55	49	43	50	35	34	26	21
Aminoglycosides	24	20	12	16	15	18	19	20	20
Total sales imm. dry cow	**126**	**120**	**94**	**101**	**106**	**98**	**102**	**100**	**90**

[1]Sales of penicillin in 2013 corrected

Appendix 3. Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

Salmonella isolates from food-producing animals were collected as required by the Finnish salmonella control programme. One isolate from each notified incident was included. Isolates from domestic food included also isolates originating from in-house control system.

Campylobacter jejuni were collected from broilers in association with the Finnish Campylobacter control programme for broilers. Between 1st of June and 31st of October, every slaughtered broiler production batch was sampled and between 1st of November and 31st of May, the frequency is set annually depending on production volume. All isolates (one isolate per slaughter batch) are included in the antimicrobial susceptibility testing.

Campylobacter spp. from fur animals were isolated from intestinal or faecal samples as part of diarrhea examination.

Animal pathogens

Clinical isolates originated from diagnostic submissions or postmortem examinations done in the former Evira laboratories. *Escherichia coli* was isolated from pigs with enteritis, the samples were taken from the contents of the gastrointestinal tract. All isolates examined were confirmed to be enterotoxigenic using PCR for toxin and fimbrial genes. *Staphylococcus aureus* from broiler tenosynovitis cases were isolated from post-mortem samples submitted to Evira. All obtained *S. aureus* isolates were included from the study period. *A. pleuropneumoniae* isolates originate from post mortem investigations of lungs most likely from pigs with respiratory disease. Bovine respiratory pathogens were mostly from deep nasopharyngeal swabs from non-medicated calves suffering from acute respiratory disease. Also isolates from post mortem investigations of cattle lungs were included. *E. coli* isolates from broilers are from post mortem samples from parent or production pedigree, and isolated either from bone marrow or heart. *Brachyspira pilosicoli* isolates are from faecal samples of swine with diarrhea.

Antimicrobial resistance figures from companion animal pathogens were collected from the clinical microbiology laboratory of the Faculty of Veterinary Medicine, University of Helsinki. All isolates included in this report originated from clinical specimens. The data were available for the period of 2014-2018.

Indicator bacteria and ESBL/AmpC/carbapenemase-producing E. coli in food-producing animals

Indicator *E. coli* was isolated from broiler caeca in 2018. From the same samples, the screening of ESBL/AmpC and carbapenemase producing *E. coli* was done. The samples from broilers (n=289) originated from healthy animals at slaughter between January and December. The sampling was evenly distributed throughout the year. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. The broiler slaughterhouses accounted approximately for >99% of the total number of slaughtered animals in Finland.

From each flock, sample was taken from one bird. The samples were taken aseptically and transported refrigerated to the laboratory within two days. Samples taken on Fridays (from one slaughterhouse) were kept refrigerated from Friday to Monday and transported to the laboratory during the following Monday.

Indicator *E. coli* isolates tested for susceptibility were randomly selected from all isolates available at the laboratory. Each isolate represented a different epidemiological unit (a flock).

ESBL/AmpC/carbapenemase-producing E. coli in meat

Randomly selected samples of packed fresh and chilled (not frozen) meat from broilers (n=300) were collected at retail between January and December in 2018. Sampling was evenly distributed throughout the year and allocated according to meat batches. Samples were collected from retail shops in six different NUTS-3 areas, covering approximately 55% of the Finnish population. The meat samples were sliced or diced and wrapped in vacuum or in a controlled atmosphere. Broiler meat samples were all of domestic origin.

The samples were transported refrigerated to the laboratory within 1 day. The temperature of the meat was measured at the laboratory at arrival. From the biggest NUTS-3 area, samples were also collected on Fridays and transported to the laboratory during the same day. One isolate from each epidemiological unit (if available) was selected for susceptibility testing.

ESBL/AmpC/carbapenemase-producing E. coli in imported poultry flocks

Imported flocks intended for broiler meat, turkey meat and egg production are screened for ESBL/AmpC- and carbapenemase-producing *E. coli* according to recommendations given by Animal Health ETT.

Isolation and identification of bacteria

Zoonotic bacteria

Salmonella spp. were isolated and identified according to a modification of the NMKL standard Nr 71 (1999), according to ISO standard 6579:2002 or ISO standard 6579:2002, Amendment 1/2007, at local food control or slaughterhouse laboratories. Serotyping of the isolates was performed at Evira, Veterinary Bacteriology Unit.

C. jejuni from broilers were isolated at slaughterhouse laboratories and confirmed at the former Evira, Food and Feed Microbiology Research Unit, according to a modified method of the NMKL 119:2007.

Isolation and identification of *C. jejuni* from fur animals was performed by accredited conventional culture and biochemical/MALDI-TOF methods in Evira in Veterinary Bacteriology and Pathology Unit.

Animal pathogens

Isolation and identification of pathogens from food-producing animals was performed by accredited conventional culture and biochemical/MALDI-TOF methods in the former Finnish Food Safety Authority, Veterinary Bacteriology and Pathology Unit.

Identification of pathogens from companion animals was performed by conventional biochemical methods (2014-2015) and since then by MALDI-TOF method in the clinical microbiology laboratory of the Faculty of Veterinary Medicine, University of Helsinki. Pathogens were from various types of specimens, such as superficial and deep pus specimens, urine, respiratory tract, and blood.

Indicator E. coli

Intestinal content was directly spread on Brilliance™ *E. coli*/coliform Selective Agar (Oxoid) and incubated overnight at 37°C. Typical, purple colonies were subsequently spread on blood agar plates and after an overnight incubation at 37°C, stored at -80°C until susceptibility testing.

Screening of ESBL-, AmpC- and carbapenemase-producing E. coli

The screenings of ESBL/AmpC- and carbapenemase-producing *E. coli* from broilers and broiler meat samples were part of the EU-wide monitoring based on Comission Decision 2013/652/EU. The EURL protocols (www. https://www.eurl-ar.eu/protocols.aspx) were used for caecal samples from broilers (n=289) and the broiler meat samples (n=300).

Briefly, 1 g of intestinal content or 25 g of fresh meat was suspended in 10 ml or 225 ml of buffered peptone water (BPW) (Merck, Germany), respectively, and incubated overnight at 37°C. Subsequently, 10 µl of the suspension was spread on MacConkey agar plates (Becton, Dickinson & Company, France) containing 1 mg/l cefotaxime (Sigma-Aldrich, Germany) for the detection of ESBL/AmpC producers, and on CARBA and OXA-48 plates (Biomerieux) for the detection of carbapenemase producers. MacConkey plates were incubated overnight at 44°C, and CARBA and OXA-48 plates overnight at 37°C. Presumptive *E. coli* colonies from the selective plates were confirmed with MALDI-TOF (Maldi Biotyper®, Bruker Daltonics, Germany).

The screening of ESBL/AmpC- and carbapenemase-producing *E. coli* from imported poultry flocks was conducted using the liners of transport boxes. As a general rule, ten liners from each import batch, were analysed as two pooled samples of five liners. Samples were analysed with the same method as ceacal and meat samples, suspending five liners in 3 liters of BPW.

Susceptibility testing

Verbal descriptions of the resistance levels are those used by EFSA (EFSA, 2010).

Rare	< 0.1%
Very low	0.1% to 1.0%
Low	>1% to 10%
Moderate	>10% to 20%
High	>20% to 50%
Very high	>50% to 70%
Extremely high	>70%

Bacteria from food-producing animals

The susceptibility testing of bacteria from food-producing animals was performed with broth microdilution method according to the Clinical and Laboratory Standards Institute (CLSI) standard VET01-A4. The susceptibility testing of animal pathogens isolated was performed with a broth microdilution method using VetMIC™ (Department of Antibiotics, National Veterinary Institute, Uppsala, Sweden) microtiter plates except for the bovine and porcine respiratory pathogens that were tested using Sensititre™ (TREK Diagnostic Systems Ltd, United Kingdom) BOPO6F plates. The susceptibility of salmonella and indicator *E. coli* was performed using Sensititre™ plates. The susceptibility of campylobacter was performed using VetMIC™

plates. The confirmation of presumptive ESBL/AmpC-producing bacteria was done by the AmpC & ESBL ID Set (D68C, Mast Diagnostics, UK) (pathogenic *E. coli* from food-producing animals) or by the microdilution method using Sensititre™ EUVSEC2 plates (salmonella, indicator *E. coli,* isolates from the ESBL/AmpC screening). Beta-lactamase activity in *S. aureus* was tested with Cefinase™ disks (Becton Dickinson, NJ, USA).

Susceptibility testing was performed at the former Evira, Food and Feed Microbiology Research Unit and for *Brachyspira* spp. at Veterinary Bacteriology and Pathology Unit. The current (October 2019) epidemiological cut-off (ECOFF) values were used to separate the wild-type population (referred as susceptible) from non-wild-type isolates (referred as resistant) (Table 28). When available, clinical breakpoints of the current CLSI documents (CLSI VET08, 2018 or CLSI M100, 2019) were used to evaluate clinical resistance. There are no standardised breakpoints approved for *Brachyspira* spp. from swine. Clinical cut-off values (Rønne at al. 1990) were applied to *B. pilosicoli* MICs.

Table 29. *Epidemiological cut-off values (mg/L) used in this report.*

Substance	*Salmonella enterica*	*Escherichia coli*	*Campylobacter jejuni*	*Campylobacter coli*	*Staphylococcus aureus*
Ampicillin	>8	>8			
Cefotaxime	>0.5	>0.25			
Cefoxitin					>4
Ceftazidime	>2	>0.5			
Chloramphenicol	>16	>16			
Ciprofloxacin	>0.06	>0.06	>0.5	>0.5	
Colistin	>2 [1]	>2			
Enrofloxacin		0,125			
Erythromycin			>4	>8	
Florfenicol	>16	>16			
Gentamicin	>2	>2	>2	>2	
Kanamycin		>2			
Meropenem	>0.125	>0.125			
Nalidixic acid	>16	>16	>16	>16	
Oxacillin					>2
Streptomycin	>16	>16	>4	>4	
Sulfamethoxazole	>256 [1]	>64			
Tetracycline	>8	>8	>1	>2	>1
Trimethoprim	>2	>2			
Trimethoprim/sulfamethoxazole[2]		>1			>0.5

[1] no ECOFF available
[2] concentration of trimethoprim given, concentration ratio with sulfamethoxazole 1:20

Bacteria from companion animals

Susceptibility testing of bacteria isolated from companion animals was performed in in the clinical microbiology laboratory of the Faculty of Veterinary Medicine with a disk diffusion technique with an available CLSI standard (CLSI VET01-A4). For all data, clinical breakpoints of the standard CLSI VET01-S2 was used to calculate non-susceptibility percentages. Resistance percentages include resistant and intermediate isolates. If veterinary breakpoints were not available, the breakpoints available in CLSI M100-S24 (2014) were used. An exception was the fucidic acid non-susceptibility breakpoint, which was ≤ 23 (FiRe-standard, version 6). Beta-lactamase activity was tested with Cefinase™ disks (Becton Dickinson, NJ, USA). *S. aureus* with oxacillin or cefoxitin MIC values >2 or >4, respectively, were tested for the presence of the *mecA* gene with polymerase chain reaction (PCR) using primers described in Murakami *et al*. (1991).

Quality assurance system

The Veterinary Bacteriology and Pathology Unit of the former Finnish Food Safety Authority, currently Finnish Food Authority participates in external quality assurance programmes for veterinary pathogens and in proficiency tests on isolation, identification and serotyping of Salmonella, and the Microbiology Unit participates in proficiency tests for antimicrobial susceptibility testing.

For susceptibility tests the following bacteria were included as quality controls on at least a weekly basis: *E. coli* ATCC 25922, *S. aureus* ATCC 29213, *C. jejuni* ATCC 33560, *Actinobacillus pleuropneumoniae* ATCC 27090 and *Histophilus somni* ATCC 700025. For *Brachyspira* susceptibility test, *Brachyspira hyodysenteriae* ATCC 31212 was used as a quality control strain.

The Veterinary Bacteriology and Pathology Unit is accredited for isolation, identification and serotyping of salmonella, and the Microbiology Unit and the Bacteriology laboratory in Seinäjoki using VetMIC™ and/or Sensititre™ susceptibility panels in the susceptibility testing according to SFS-EN ISO/IEC 17025, by the Finnish Centre for Metrology and Accreditation.

The clinical microbiology laboratory of the Faculty of Veterinary Medicine laboratory has internal quality control scheme with ATCC control strains; the quality control tests are performed on a weekly basis. In addition, the laboratory participates in several external quality control schemes (including identification and susceptibility testing of bacteria) organised by Labquality and VETQAS.

Appendix 4. Salmonella serovars isolated from food-producing animals in 2018

Table 30. *Salmonella enterica serovars isolated from the main food-producing animal species in Finland in 2018.*

Serotype	Nr of isolates	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
***S.* Typhimurium**	22	15	6	1	
***S.* Enteritidis**	6	5	1		
***S.* Kentucky**	4	4			
***S.* Konstanz**	2	2			
***S.* Senftenberg**	2	2			
***S.* Tennessee**	1	1			
***S.* Chester**	1	1			
***S.* Newport**	1	1			
***S.* Derby**	1		1		
***S.* Montevideo**	1		1		
***S.* Hessarek**	1		1 (carcass)		
***S.* Hvittingfoss**	1			1	

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