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FINRES-Vet 2020

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

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UNIVERSITY OF HELSINKI
FACULTY OF VETERINARY MEDICINE

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Authors and institutions participating in making the FINRES-Vet report

Finnish Food Authority Ruokavirasto

Suvi Nykäsenoja, Satu Olkkola, Tarja Pohjanvirta, Mia Biström, Liisa Kaartinen, Saija Kalenius, Henriette Helin-Soilevaara, Mirja Raunio-Saarnisto, Katariina Pekkanen, Thomas Grönthal

Finnish Medicines Agency Fimea

Katariina Kivilahti-Mäntylä, Tita-Maria Muhonen

Faculty of Veterinary Medicine, University of Helsinki

Katarina Eskola, Thomas Grönthal

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Abstract

Sales of antibiotics for use in animals in Finland in 2020 were lower than ever reported. The decreased sales from 2019 to 2020 was largely attributed to decreased manufacturing of medicated feed to fur animals. The majority, almost three quarters, of all antimicrobial products were given to individual animals, and products intended for group treatment accounted for just over one quarter. The most-sold antimicrobial continues to be injectable penicillin followed by orally administered sulfonamide-trimethoprim combinations and orally administered tetracyclines. Sales of reserve antimicrobials (HPCIA, WHO list) for the treatment of animals remained very low also in 2020.

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

Among salmonella and campylobacter from Finnish food-producing animals, resistance levels were low. Since 2014, the proportions of fluoroquinolone and tetracycline resistant broiler campylobacter isolates have varied. In bovine campylobacters, especially fluoroquinolone resistance has increased in the 2010's.

Resistance situation among indicator *E. coli* from broilers and cattle has remained good. The prevalence of ESBL/AmpC-producing bacteria in slaughtered broilers and in broiler meat at retail has decreased significantly and was very low in 2020. ESBL/AmpC bacteria were detected at low level from slaughtered cattle.

The development of resistance situation among pathogenic bacteria isolated from food-producing animals varied between bacterial species but changes were overall small. Resistant isolates were still detected most commonly among enterotoxigenic *E. coli* from pigs. Among bacteria isolated from companion animals, the development of resistance situation varied during the follow-up period, and the slow decrease in resistance did not continue as clearly. Among canine *E. coli* strains that were resistant to third-generation cephalosporins, the relative proportion of AmpC producers increased, and ESBL strains were less common.

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Tiivistelmä

Eläinten antibiootteja myytiin Suomessa 2020 vähemmän kuin koskaan aikaisemmin seurannan aikana. Vähentynyt antibioottien myynti vuodesta 2019 vuoteen 2020 johtuu varsinkin turkiseläinten lääkerehun valmistuksen vähenemisestä. Suurin osa, lähes kolme neljäsosaa antibiooteista annettiin eläinyksilöille ja ryhmälääkkeiden osuus oli reilu neljännes. Eniten käytetty antibiootti oli injektiopenisilliini, seuraavina suun kautta annettava sulfonamidi-trimetopriimi-yhdistelmä ja tetrasykliinit. Ihmisen reserviantibioottien (HPCIA, WHO:n lista) myynti eläinten lääkintään pysyi edelleen erittäin vähäisenä.

Eläimistä ja elintarvikkeista eristettyjen bakteerien antibioottiresistenssitilanne Suomessa on pysynyt suhteellisen hyvänä. Joillakin bakteereilla resistenssiä kuitenkin esiintyy kohtalaisesti tai yleisesti, joten eläinten antibioottien käyttötarpeen vähentämiseen ja hallittuun antibioottien käyttöön tulee jatkossakin kiinnittää huomiota. Eläimille annettuja mikrobilääkkeiden käyttösuosituksia on tärkeää noudattaa.

Kotimaisista tuotantoeläimistä eristetyillä salmonelloilla ja broilereista eristetyillä kampylobakteereilla resistenssiä todettiin vähän. Vuodesta 2014 alkaen broilereista eristetyillä kampylobakteereilla on todettu vaihtelevasti resistenssiä fluorokinoloneille ja tetrasykliinille. Myös nautojen kampylobakteereilla erityisesti fluorokinoloniresistenssi on 2010-luvulla lisääntynyt.

Broilereista ja naudoista eristettyjen *E. coli* -indikaattoribakteerien resistenssitilanne on pysynyt hyvänä. ESBL/AmpC -bakteereiden esiintyminen on vähentynyt merkittävästi suomalaisissa teurasbroilereissa ja vähittäismyynnissä olevassa broilerinlihassa. Teurasnaudoilla ESBL/AmpC-bakteereita todettiin vähän.

Tuotantoeläinten patogeenien resistenssitilanteen kehitys vaihteli eri taudinaiheuttajilla, mutta muutokset eivät olleet suuria. Eniten resistenssiä todettiin sikojen enterotoksisilla *E. coli* -kannoilla. Seura- ja harraste-eläimistä eristettyjen bakteerien resistenssitilanteen kehitys vaihteli seurantajakson aikana eikä aiemmin havaittu hidas resistenssin väheneminen jatkunut yhtä selkeänä. Kolmannen polven kefalosporiineille vastustuskykyisten koirien *E. coli* -kantojen joukossa AmpC-tuottajien suhteellinen osuus on lisääntynyt ja ESBL-kannat ovat entistä harvinaisempia.

Beskrivning

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Försäljningen av antibiotika för djur i Finland år 2020 var lägre än någonsin. Den minskade försäljningen från 2019 till 2020 kan i stora drag förklaras med den minskande tillverkningen av läkemedelsfoder till pälsdjur. Största delen, nästan tre fjärdedelar av antibiotika, ges till djurindivider och drygt en fjärdedel används som gruppläkemedel. Det mest använda antibiotikan var penicillin i injektionsform, följt av oralt administrerade sulfonamid-trimetoprim kombinationer och tetracykliner. Försäljningen av reservantibiotika (HPCIA, WHO:s lista) för behandling av djur var fortsättningsvis mycket låg.

Resistenssituationen hos bakterier som har isolerats från djur och livsmedel är fortvarande relativt god i Finland. Hos vissa bakterier var förekomsten av resistens ändå måttlig eller vanlig. Därför ska uppmärksamhet fortvarande ägnas åt åtgärderna för att minska behovet av att använda antibiotika för djur och för att kontrollera användningen av antibiotika. Det är viktigt att följa rekommendationerna för användning av antimikrobiella medel för djur.

Hos salmonellabakterier som isolerats från finska livsmedelsproducerande djur och kampylobakterier som isolerats från broilrar konstaterades endast en liten resistens. Sedan 2014 har resistens mot fluorokinoloner och tetracykliner konstaterades i varierande grad hos Campylobacter som har isolerats från slaktkycklingar. Hos kampylobakterier som isolerats från nötkreatur har resistens särskilt mot fluorokinoloner ökat på 2010-talet.

Resistenssituation hos *E. coli* -indikatorbakterier som isolerades från broilrar och nötkreatur har varit fortsatt god. Förekomsten av ESBL/AmpC-bakterier hos finska slaktbroilrar och i inhemskt broilerkött som såldes i detaljhandeln har minskat betydligt och var väldigt låg år 2020. Hos slaktad nötkreatur har ESBL/AmpC-bakterier påvisats lite.

Utvecklingen av resistenssituationen av patogener som har isolerats från livsmedelsproducerande djur varierade men förändringarna var inte stora. Resistensen var vanligast hos enterotoxiska *E. coli* -stammar från svin. Bland bakterier isolerade från sällskaps- och hobbydjur varierade utvecklingen av resistenssituation under uppföljningsperioden och den långsamma minskningen av resistens fortsatte inte lika tydligt. Bland hundars *E. coli*-stammar som är resistenta mot tredje generationens cefalosporiner har andelen AmpC producerade ökat och ESBL-stammar var allt mer sällsynta.

CONTENTS

Introduction

FINRES-Vet 2020 reports statistics on sales of veterinary antibiotics and antibiotic resistance in bacteria isolated from animals and food. This report covers the latest results from 2020 but includes data also from previous years to enable a follow-up of trends.

FINRES-Vet programme is coordinated by the Finnish Food Authority. Other collaborators are the Finnish Medicines Agency (Fimea) and the University of Helsinki. The Finnish Food Authority coordinates the FINRES-Vet programme and monitors antibiotic resistance in bacteria from food-producing animals. The Finnish Medicines Agency monitors sales of veterinary antibiotics, and Finnish Food Authority the use of feed additives and medicated feeds. The Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine (University of Helsinki) provides antibiotic susceptibility data from companion animals and horses.

In 2020, antibiotic resistance was monitored in zoonotic and indicator bacteria from production animals along with resistance of certain animal pathogens from clinical submission isolated from production and companion animals. Due to COVID-19 pandemic, sampling at the slaughterhouses and at retail shops was partly suspended from the beginning of April until the end of May 2020. The sampling plan was reassessed during autumn 2020 and adjustments to the national sampling plan (in accordance with EFSA mandatory resistance monitoring, Commission Implementing Decision 2013/652/EU) were made so that the target number of samples would be achieved.

Monitoring resistance in zoonotic bacteria is important as resistance can transfer between bacteria, animals, and humans, creating a risk also to human health. Resistance in animal pathogens needs monitoring in order to recognise emerging resistance traits, and to indicate effectiveness of antibiotic treatments and whether prudent use guidelines to veterinarians are up to date. 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 uncommonly severe or recurrent infections. The resistance of indicator bacteria in a given population reflects the selection pressure caused by the use of antibiotics. Indicator bacteria constitute a major component of intestinal microbiota and their genomes can also function as a reservoir of resistance genes, which may be transferred to pathogenic bacteria.

FINRES-Vet programme has the following objectives:

- to monitor the consumption of antibiotics used in veterinary medicine,
- to monitor antibiotic resistance in bacteria from major food-producing animals, food, and companion animals,
- 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.

During the FINRES-Vet monitoring period, the overall resistance situation in bacteria isolated from animals and food of animal origin in Finland has been favourable. This is probably due to the long history of strict antibiotic policy, and active promotion of health and welfare of food-producing animals i.e. preventive measures. National prudent use guidelines recommend choosing narrow spectrum antibiotics and individual treatment whenever possible (Evira, 2016). Overall sales of veterinary antibiotics in Finland have been low, the sales in 2020 being the lowest since reporting began. Penicillin is the most used antibiotic and majority of antibiotics are given to individual animals. Increase in resistance in some zoonotic bacteria and certain animal pathogens has been observed in recent years. This highlights the importance of long-term monitoring of antibiotic resistance and indicates that preventive measures need further improvement and the prudent use guidelines should be strengthened.

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

1.1 Changes in animal population

Changes in the number of food-producing animals from 2019 to 2020 were relatively small. The decreasing trend in the number of pigs stopped and a moderate increase can be seen. However, number of cattle continued to decrease slowly. A slow increase in the number of poultry also continued (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 are used for calculating Population Correction Unit (PCU) which takes into account both number of animals and their weights. Since 2010, the PCU has decreased by 5% from 520 to 494 (thousand tons).

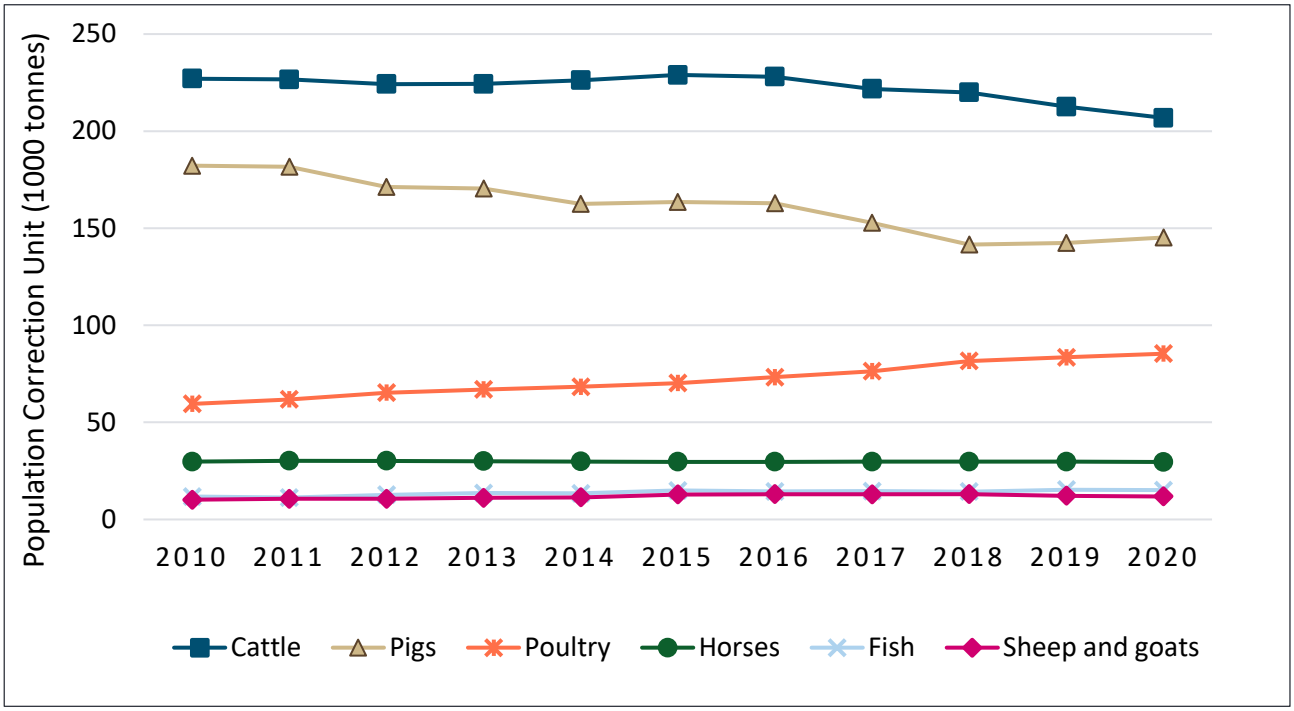

Figure 1. *Changes in food-producing animal population in Finland in 2010–2020, PCU (1000 tonnes). Detailed data on the PCU of food-producing animals in a tabulated form is presented in Appendix 1.*

Regarding the number of companion animals, Statistics Finland estimated that the number of dogs and cats in 2016 was about 700 000 and 600 000, respectively. More current data is not available.

1.2 Therapeutic antibiotics

1.2.1 Background and methodology

Finnish Medicines Agency Fimea monitors the sales of veterinary antibiotics based on statistics obtained from pharmaceutical wholesalers. Sales data reported as kg active ingredient is available since 1995. This report includes data for 2010–2020. For a review of data for 1995–2009, see the FINRES-Vet reports covering the corresponding years.

In 2010, data collection method was harmonised with the protocol of European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. Data covers also veterinary antibiotics sold with special license (exemption from marketing authorisation, i.e. veterinary antibiotic products obtained from another Member State and permitted to be released for consumption for use in specified animal species). In 2020 their proportion was approximately 5.6%. In 2021, the ESVAC protocol was revised and the conversion factors for certain derivatives or compounds of antibiotics were reassessed (ESVAC, 2021). ESVAC updates include conversion factors for benzylpenicillins and benzathine derivatives, and as a consequence, sales figures particularly for the most-sold antibiotic class for animals in Finland are affected (see Fact box 1).

Sales data are presented as kg active ingredient for overall sales and sales by different pharmaceutical forms (i.e. injectables, antibiotics administered orally, intramammaries and tablets). For intramammaries, also sales of tubes per cow is reported.

It should be noted that dosing of antibiotics varies between and within antibiotic classes, and between animal species treated. In addition, sales expressed as kg active ingredient does not take into account changes in animal populations and hence when observing such sales data, it is important to compare trends in sales of antibiotics to the same class over a longer period of time.

To compare changes in annual sales of antibiotics, the data should be in proportion to the population of animals in the given period. In this report, a population correction unit (PCU) is used. One PCU corresponds approximately to one kg and represents an estimate of the amount of livestock and slaughtered animals each year. PCU is strictly a technical unit and covers the population of major food-producing species. PCU was developed within the ESVAC project and a detailed description is available in ‘Trends in the sales of veterinary antimicrobial agents in nine European countries: Reporting period 2005–2009‘ (EMA, 2011).

Population adjusted sales, mg active ingredient per PCU (mg/PCU) are presented in this report only for the EU indicators of veterinary antibiotics applicable in Finland. Consumption is reported for overall sales, sales of fluoroquinolones and 3rd generation cephalosporins (ECDC, EFSA and EMA, 2017). PCU adjusted data does not include tablets, as they are almost exclusively used in companion animals. Only estimates of the number of dogs and cats in Finland are available. Therefore, sales of tablets cannot be adjusted to the population of companion animals, and they are presented in a separate figure, as kg active ingredient.

Fact box 1. Impact of updated conversion factors

Updated conversion factors (ESVAC, 2021) were applied for the 2020 data and the results for 2010–2019 were recalculated where relevant. Therefore, historical results in the previous FINRES-Vet reports may differ slightly from the results of the 2020 report. Recalculation of historical data for 1995–2009 was not possible due to technical reasons.

Recalculated annual overall sales in 2010–2019 were on average 2.2% (266 kg) lower compared to the results obtained with the old conversion factors. Sales of injectable penicillins, penicillins in intramammaries for the lactation period, and penicillins in dry cow products were approximately 6.2% (258 kg), 6.6% (6 kg) and 5.3% (2 kg) lower compared to the old method. For population corrected overall sales (primary EU indicator), the difference was on average -2.6% (-0.5 mg/PCU) per year.

1.2.2 Overall sales (kg active ingredient)

Overall sales of veterinary antibiotics in 2020 was 8 933 kg and is the lowest ever reported in Finland. Decrease from 2019 to 2020 was 14% (-1 503 kg) (Figure 2, Table 24 in Appendix 2). A decrease was noted especially in sales of tetracyclines, sulfonamide-trimethoprim combinations and lincosamides, as well as for seven other antibiotic classes whereas sales of penicillins and fluoroquinolones increased.

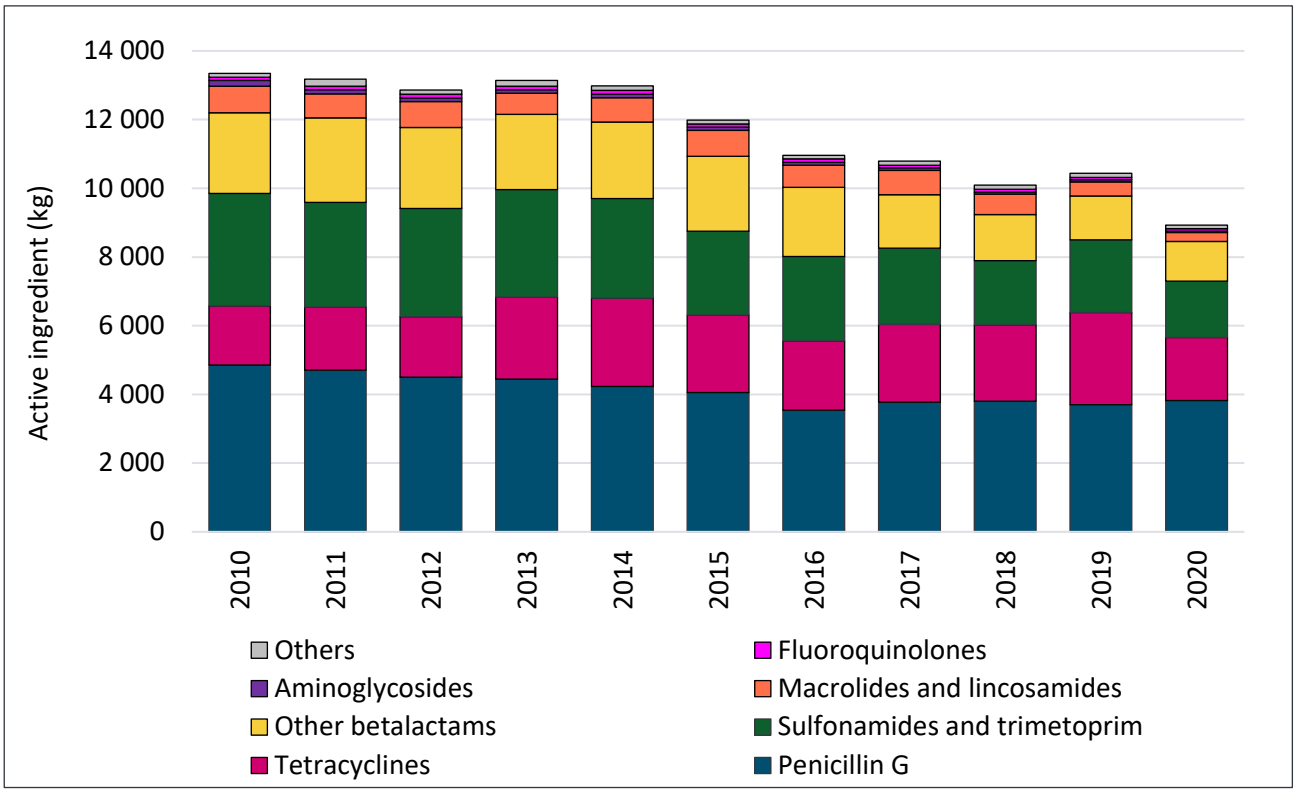

***Figure 2**. Overall sales (kg active ingredient) by class. Other betalactams = aminopenicillins, cephalosporins and cloxacillin. Others = pleuromutilines, amphenicol and imidazole derivatives. For detailed data in tabulated form see Appendix 2.*

Over two thirds of antibiotics sold (in kg active ingredient) in 2020 were for treatment of individual animals (injectables, tablets, oral pastes and intramammaries). The proportion of products applicable for group treatment (premixes, oral powders, and oral solutions) was less than one third of the overall sales (Figure 3).

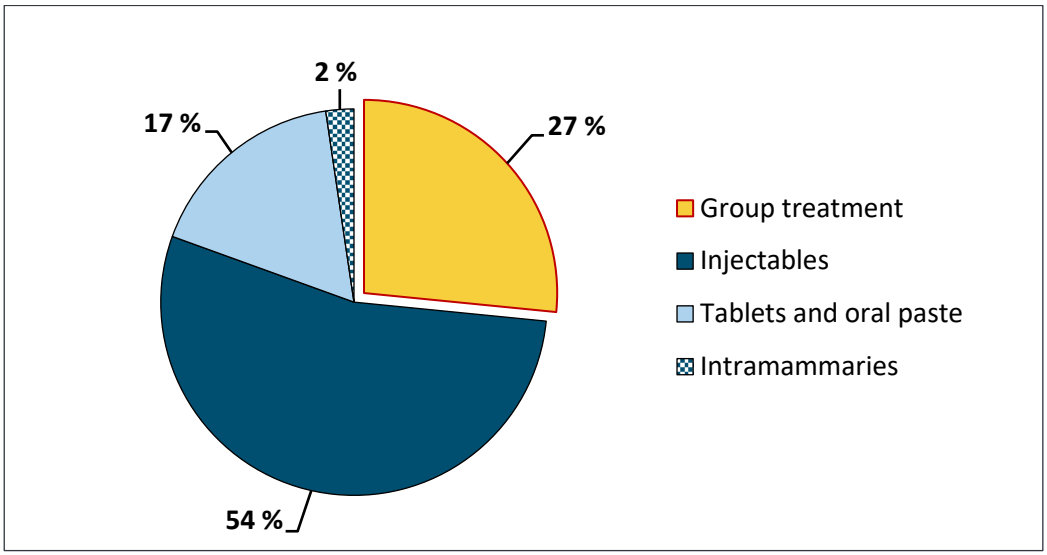

***Figure 3**. Sales of veterinary antibiotics by form in 2020. Group treatment: premixes, oral solutions, and oral powders*.

The most-sold antibiotics were benzylpenicillin (43%), tetracyclines (20%) and sulfonamide-trimethoprim combinations (18%) (Figure 2). Three antibiotic groups of the World Health Organization list (WHO, 2019) of highest priority critically important antibiotic 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 2%, fluoroquinolones 0.8% and 3rd generation cephalosporins 0.002%).

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

Over half of the antibiotics sold were products administered as injections to animals (Figure 3, Table 24 in Appendix 2). By far the most sold injectable was penicillin (74% of all injectables) followed by tetracyclines and aminopenicillins (Figure 4A). A decrease from 2019 to 2020 was noted in sales of tetracyclines (-13%), aminopenicillins (-18%) and sulfonamide-trimetoprim combinations (-14%). An increase was observed for sales of lincosamides (24%) and fluoroquinolones (11%).

The most-sold orally administered antibiotic in 2020 was sulfonamide-trimetoprim-combinations, followed by tetracyclines and aminopenicillins (Figure 4B). Sales of products administered orally has been relatively stable during the last decade but in 2020 turned to a marked decrease after peaking in 2019 (Table 25 in Appendix 2). The reduction in sales from 2019 to 2020 is seen in almost all antibiotic classes, but especially in tetracyclines (-39%, 750 kg) and sulfonamide-trimethoprim combinations (-25%, 434 kg). Noteworthy is that the increased sales of these two classes also largely explain the changes in overall sales in 2019.

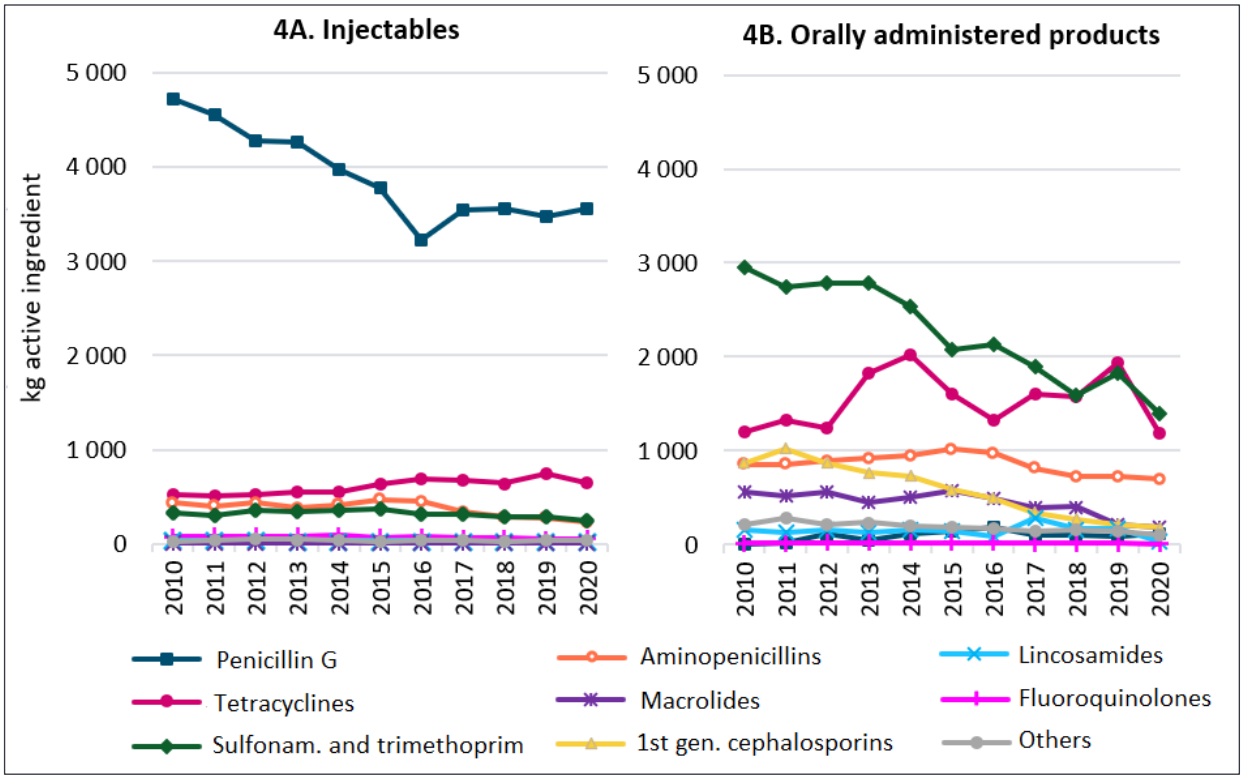

***Figure 4A and 4B**. Trends in sales of injectable veterinary antibiotics (4A) and sales of orally administered veterinary antibiotics (4B). Other injectables: amphenicols, aminoglycosides and cephalosporins, Other oral products: amphenicols, aminoglycosides, pleuromutilins and imidazole derivatives. For detailed data in tabulated form see Appendix 2.*

An inspection of the monthly sales of tetracyclines and sulfonamide-trimethoprim combinations revealed that in autumn 2019 a shortage of in-feed administered tetracycline was followed by a major increase in sales of other in-feed administered veterinary medicinal products. Although species-specific data is not available, the increase in overall sales in 2019 can be linked to veterinarians treating fur animals. It is however not known whether increased sales in 2019 were simply due to stock up or actual increased use in fur animals. In 2020, the decrease in overall sales was accompanied by a marked reduction in the number of fur animals (-30%) (FIFUR, 2021) and a prominent decrease in the volume of medicated feed manufactured for fur animals (-85%) (Finnish Food Authority, 2021a). The statistics on medicated feed do not capture medicines mixed in feed on the farms, but the observed changes support the assumption that the changes noted in overall sales and sales of antibiotics administered orally in 2019–2020 were largely due to changes in antibiotic treatment of fur animals (see Fact box 2).

Veterinary antibiotic tablets are almost solely used for treatment of companion animals. In the 2010's their sales more than halved (Figure 5) which is mainly due to reduced sales of 1st generation cephalosporins (-82%) from 2011 to 2020 (Figure 5). The decreasing trend continued also for sales of aminopenicillins (-7%) and fluoroquinolone tablets (-9%) whereas sales of lincosamide tablets increased by 14% from 2019 to 2020.

Updated statistics on the number of companion animals are not available but it has been estimated that the number of dogs and cats has increased slightly during the last decade (Statistics Finland, 2016). In addition, there is no information on the volume of human antibiotics prescribed for companion animals as

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.

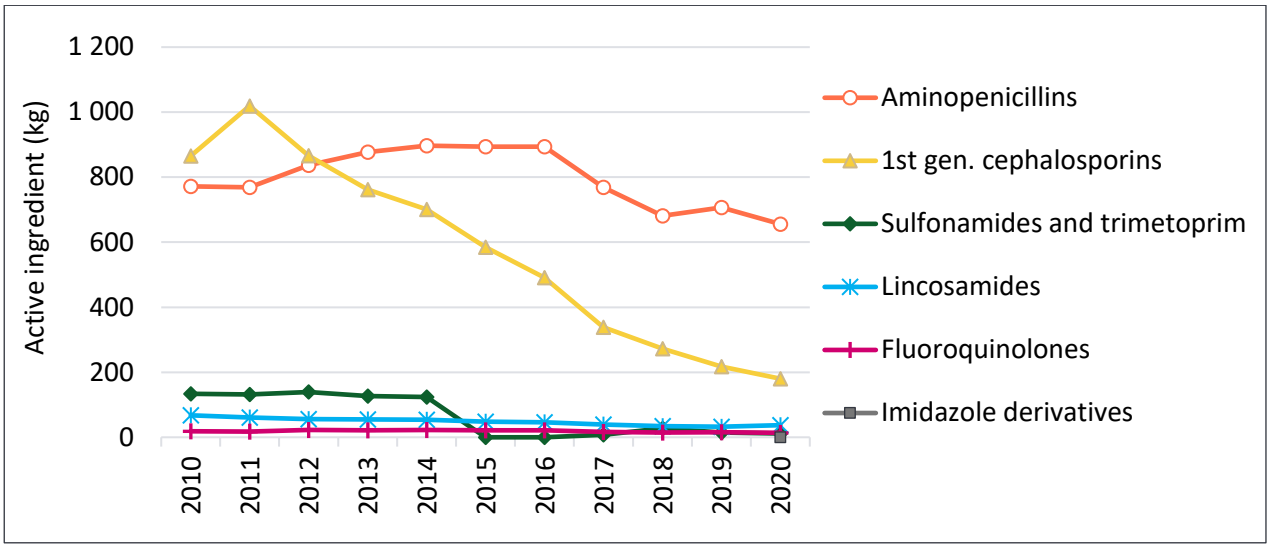

Figure 5. *Sales of antibiotic tablets to companion animals (kg active ingredient) by class. Note that sulfonamide and trimetoprim combination tablets were withdrawn from the market in 2015 and are currently available only on special licence.*

The number of antibiotic products for the use during the lactation period sold per dairy cow increased by 5% since 2019 but was still 47% less than in 2011 (Figure 6). Penicillin continues to be the most-used antibiotic both during lactation and dry period (Table 27, Appendix 2). The number of antibiotic products sold for dry cow treatment per dairy cow increased by 5% since 2019 and was 2% higher compared to 2011.

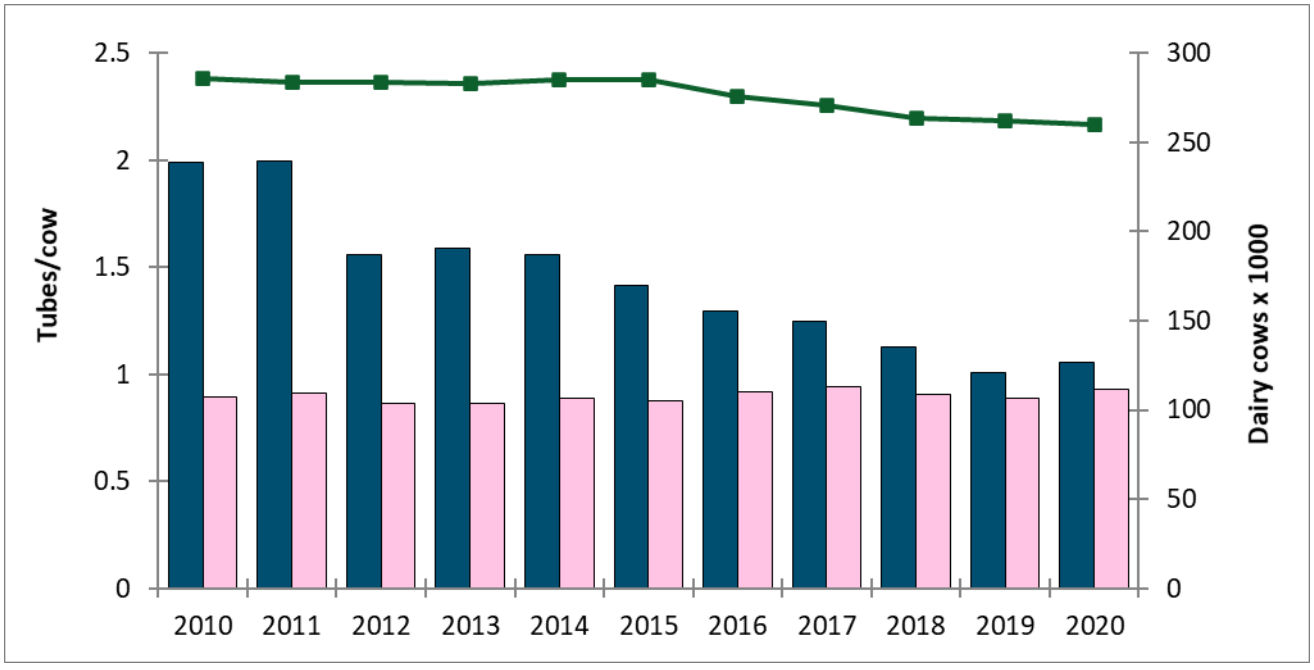

Figure 6. *Antibiotics for intramammary use per cow during lactation period (blue column) and for dry cow period (pink column) and the number of dairy cows (green curve).*

1.2.4 EU-indicators of antibiotic 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 antibiotics and occurrence of antibiotic resistance in both humans and food-producing animals (ECDC, EFSA ja EMA 2017). Of these, overall sales of veterinary antibiotics, sales of 3rd generation cephalosporins and sales of fluoroquinolones measured in mg/PCU are applicable for food-producing animals in Finland.

All other pharmaceutical forms except tablets are included in the calculations of population corrected sales in food-producing animals, as veterinary tablets are almost solely used for treatment of companion animals. It should be taken into account that injectable antibiotic products are often authorised for both food-producing and companion animals. However, it has been estimated that volume of use of injectable antibiotics in companion animals is minor (measured as kg active ingredient) and therefore such sales can be included in the overall sales for food-producing animals (EMA, 2020). For certain injectable antibiotic classes that are only marketed for use in companion animals and foals, e.g. 3rd generation cephalosporins, their inclusion results in overestimation of the use in food-producing animals.

Overall sales of veterinary antibiotics for food-producing animals remained at a very low level, 16.3 mg/PCU (Table 1), corresponding to a 2.8 mg/PCU (-15 %) reduction since 2019 and a decrease of 5.1 mg/PCU (-24%) since 2011, being the lowest since reporting began. Sales of fluoroquinolones increased somewhat in 2020 (11%, 0.01 mg/PCU) but continued to be at a very low level with 2020 sales being the second lowest figure (0.11 mg/PCU) in the decade. Sales of 3rd generation cephalosporins have reduced by 98% (-0.02 mg/PCU) since 2011 and their sales are at an extremely low level (0.0004 mg/PCU).

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

Sales (mg/PCU)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Overall sales[1]	22.1	21.4	21.3	21.9	21.8	20.1	18.2	18.9	18.1	19.1	16.1
Fluoroquinolones	0.15	0.16	0.16	0.16	0.18	0.14	0.15	0.12	0.13	0.10	0.11
3rd generation cephalosporins[2]	0.009	0.017	0.029	0.016	0.016	0.014	0.006	0.001	0.001	0.0005	0.0004

[1] Penicillin conversion factors updated in accordance with ESVAC protocol rev. 4 in 2021 and overall sales in 2010–2019 was recalculated. [2] Since 2017, sales of 3rd generation cephalosporins only for treatment of foals and companion animals.

For decades already the strategic policy in Finland has been to reduce the need for antibiotic treatment by eradicating infectious animal diseases, using efficient biosecurity measures and herd health programs to achieve good animal health. If antibiotics, however, are needed, their use should be cautious in accordance with the national prudent use guidelines (available since 1996, updated three times, last in 2016). In 2014, a requirement of susceptibility testing before using the highest priority critically important antibiotics was added in legislation. Thereafter control actions were targeted to high-prescribing veterinarians of 3rd generation cephalosporins, which has proven efficacious. An overview of the strategic actions implemented since 1949 is available at the Finnish Food Authority website (Finnish Food Authority, 2021b). Altogether, the comprehensive and efficient control policies have resulted in low overall sales of veterinary antibiotics, and very low to extremely low sales of antibiotics critically important in human medicine.

Fact box 2. Impact of antibiotics in medicated feed for fur animals on the population corrected overall sales

The same medicinal products are used both for fur animals and food-producing animals. However, sales data for fur animals may be examined separately as they are not food-producing animals.

The vast majority of antibiotics is administered to fur animals in medicated feed that is manufactured in feed mills. Antibiotics may also be administered to fur animals as injections. This use, nevertheless, is estimated to be minor compared to the volume of antibiotics administered in medicated feed.

Observations in antibiotic sales in 2019 and 2020 indicate that the volume of antibiotics used for treatment of fur animals may have a distinct impact on the overall sales of antibiotics used in animals and hence affect the primary indicator of veterinary antibiotic consumption i.e. overall sales in food-producing animals (mg/PCU). To estimate this effect, the volume of antibiotics in medicated feed of fur animals (Finnish Food Authority, 2021a) (kg active ingredient) was subtracted from overall sales between 2010 to 2020 and the population corrected sales were recalculated.

Population corrected sales (mg/PCU) after extracting the volume of antibiotics in medicated feed for fur animals in 2010–2020 was on average 0.9 mg/PCU smaller (-4%) compared to overall sales (variation from -0.2 to -1.8 mg/PCU) (Figure 7). Changes in the volume of medicated feed containing antibiotics for use in fur animals in 2019–2020 thus largely explain the increase noted in overall sales in 2019 and the subsequent drop in 2020.

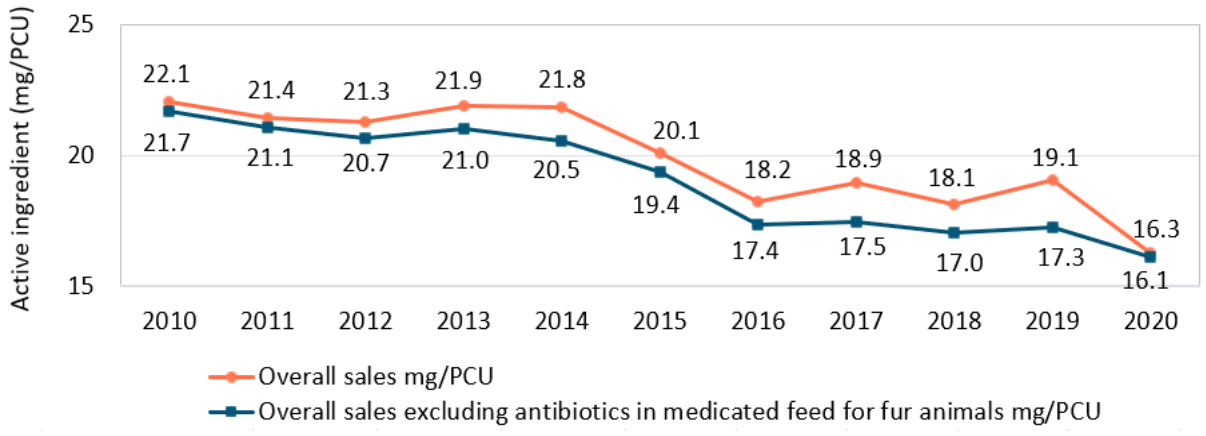

Figure 7. *Overall sales of veterinary antibiotics (mg/PCU) including (blue line) and excluding the volume of antibiotics in medicated feed for fur animals (orange line).*

1.3 Coccidiostats and antibiotic feed additives

Finnish Food Authority monitors the annual consumption of feed additives by collecting data from feed manufacturers. In 2020, only coccidiostats monensin natrium and narasin were used as prophylactic anti-parasitic agents mainly in broiler and turkey production. The overall use of coccidiostats decreased slightly from 2016 to 2018 but has since increased again in 2019 and 2020 (Table 2). Compared to the year 2010, the use of coccidiostats has increased approximately by 50%.

Table 2. *The use of coccidiostats, antibiotic and other substances in feed in Finland 2010–2020 (kg active substance/year).*

Substance	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Coccidiostats											
Decoquinate	0	0	0	0	0	0	0.1	0	0	0	0
Diclazuril	0	0	0	0	0	0	0	0.8	0.5	0.04	0
Lasalocid sodium	1.4	0	0	0	0	0	0	0	1 336	0	0
Madmuramycin ammonium	0	0	0	0	0	0	0	0	0	0	0
Monensin natrium	6 801	5 837	7 300	4 614	6 677	12 640	15 373	14 693	5 097	13 979	14 710
Narasin	5 859	7 658	6 567	9 626	9 022	5 478	5 026	4 918	13 152	6 535	6 084
Salinomycin	1 701[1]	495[2]	0	0	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0	0	0
Antibiotic substances											
Avoparcin	0	0	0	0	0	0	0	0	0	0	0
Flavomycin	0	0	0	0	0	0	0	0	0	0	0
Carbadox	0	0	0	0	0	0	0	0	0	0	0
Olaquindox	0	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	0
Dimetridazole	0	0	0	0	0	0	0	0	0	0	0
Nifursol	0	0	0	0	0	0	0	0	0	0	0
Total	**13 832**	**13 991**	**13 867**	**14 240**	**15 699**	**18 117**	**20 399**	**19 613**	**18 585**	**20 514**	**20 795**

[1] 121 kg and [2] 58 kg used in exported feed mixtures

2 Antibiotic resistance in zoonotic bacteria

2.1 Salmonella from 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 (1030/2013; 1037/2013; 134/2012). 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. The results of the programme show that salmonella is rare in food-producing animals and foods of animal origin in Finland. Salmonella isolates from the control programme are tested for antibiotic 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 2020, 37 salmonella isolates from food-producing animals (including carcass samples) were tested for susceptibility. Most of the isolates originated from cattle (n=22) and pigs (n=10). Five isolates originated from *Gallus gallus*. The most common serotypes were *S*. Typhimurium (n=13) and *S*. Enteritidis (n=6). Other serotypes are shown in Appendix 4.

Resistance in salmonella from food-producing animals was overall low (Table 3). Monophasic *S*. Typhimurium was found in two cases and one of them showed a typical multi-resistance pattern (ampicillin, sulfamethoxazole, trimethoprim). Multiresistant monophasic *S*. Typhimurium was found from piglet-producing farm from where a monophasic *S*. Typhimurium isolate with similar phenotypic resistance profile was found also in 2019.

In five cases, minimum inhibitory concentration (MIC) values for colistin exceeded >2 µg/mL which is the cut-off value used in EU resistance monitoring according to Commission implementing Decision 2013/652/EU. These five isolates included serotypes Typhimurium, Enteritidis, Konstanz and Bispebjerg. Three of these isolates (S. Typhimurium, S. Konstanz and S. Bispebjerg isolated from cattle) were subjected to whole-genome sequencing but no known resistance mechanisms for colistin were found. However, it is well known that certain serotypes give higher MIC values without known resistance mechanisms. Currently, European Committee on Antimicrobial Susceptibility Testing (EUCAST) gives no epidemiological cut-off for salmonella except for a tentative cut-off for Salmonella Dublin (>16 µg/mL).

Resistance situation of salmonella isolated from Finnish food-producing animals has been very favourable for a long time and multidrug resistance has overall been very rare (Figure 8). However, multiresistant salmonella has been detected in food-producing animals in Finland now in three consecutive years (Figure 8).

Table 3. *Distribution of MICs for Salmonella enterica from food-producing animals in 2020 (n=37).*

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	>1024
Ampicillin	2.7	0.5–13.8							43.2	54.1						2.7				
Azithromycin	0.0	0.0–9.4									35.1	43.2	21.6							
Cefotaxime	0.0	0.0–9.4					91.9	8.1												
Ceftazidime	0.0	0.0–9.4						83.8	16.2											
Chloramphenicol	0.0	0.0–9.4										70.3	29.7							
Ciprofloxacin	2.7	0.5–13.8	10.8	64.9	21.6		2.7													
Colistin[1]									35.1	51.4	10.8	2.7								
Gentamicin	0.0	0.0–9.4						59.5	32.4	8.1										
Meropenem[2]	0.0	0.0–9.4		40.5	59.5															
Nalidixic acid	2.7	0.5–13.8									64.9	32.4					2.7			
Sulfamethoxazole[3]	2.7	0.5–13.8										8.1	54.1	29.7	5.4					2.7
Tetracycline	2.7	0.5–13.8								86.5	10.8					2.7				
Tigecycline[4]							37.8	62.2												
Trimethoprim	0.0	0.0–9.4					35.1	62.2	2.7											

Bold vertical lines indicate current (1.7.2021) EUCAST epidemiological cut-off (ECOFF) 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]For colistin, a tentative EUCAST ECOFF is available only for *Salmonella* Dublin (>16), and because the natural susceptibility for colistin differs between serovars, no interpretation of resistance is shown. [2]EUCAST ECOFF for meropenem was previously >0,125, a current (1.7.2021) tentative cut-off value has been lowered to >0,06. [3]For sulfamethoxazole, no EUCAST ECOFF is available, therefore, a cut-off value of >256 µg/mL is used (dashed vertical line) for resistance monitoring purposes. [4]For tigecycline, EUCAST ECOFF is not available.

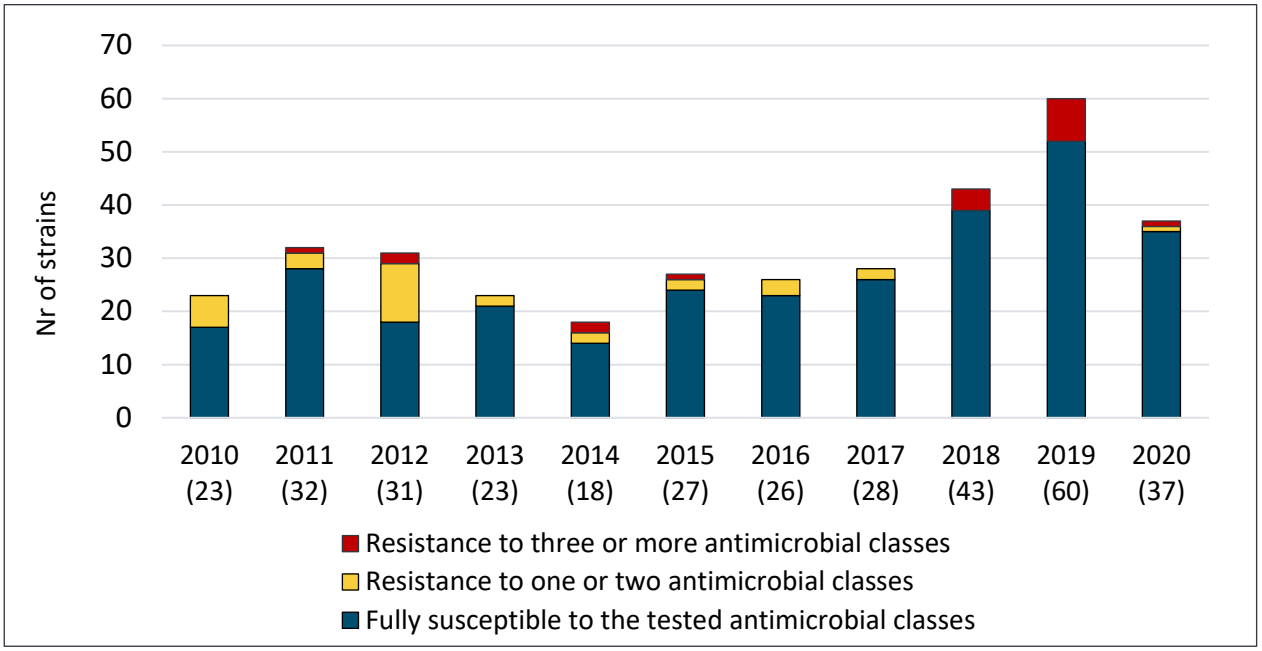

***Figure 8**. The number of sensitive and resistant salmonella isolates from food-producing animals in Finland in 2010–2020. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides, beta-lactams, phenicols, quinolones, sulfonamides, tetracyclines and trimethoprim.*

2.2 Campylobacter from food-producing animals

In 2020, as in previous years, *Campylobacter jejuni* isolates from broilers were obtained from the national Campylobacter control programme. In addition, *C. jejuni* was isolated from cattle.

2.2.1 *Campylobacter jejuni* from broilers

Within the national Campylobacter control programme of broilers in 2020, 87 *C. jejuni* isolates were tested for susceptibility, which also represents the number of campylobacter-positive broiler slaughter batches in the same year. Of these, three (3.4%) were resistant to quinolones (ciprofloxacin, nalidixic acid) and two isolates (2.3 %) were resistant to tetracycline. Resistance to the other studied antibiotics was not detected (Table 4).

Antibiotic resistance in *Campylobacter* from broilers has been monitored systematically since 2003. The numbers of resistant isolates of *C. jejuni* have been quite stable until the year 2013 and the occurrence of resistant isolates has been mainly at a low level (Figure 10). 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 peaks observed in 2014, 2016 and 2018. In 2014 and 2016, quinolone resistance was commonly accompanied with tetracycline resistance but in 2018 and 2019, tetracycline resistance was not observed. In 2020, the proportion of quinolone resistant isolates dropped further to a low level.

Table 4. *Distribution of MICs for Campylobacter jejuni from broilers in 2020 (n=87).*

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	3.4	1.2–9.7	95.4	1.1					3.4					
Erythromycin	0.0	0.0–4.2				100								
Gentamicin	0.0	0.0–4.2			14.9	85.1								
Nalidixic acid	3.4	1.2–9.7					1.1	94.3	1.1			2.3	1.1	
Streptomycin	0.0	0.0–4.2			1.1	10.3	77.0	11.5						
Tetracycline	2.3	0.6–8.0			97.7					1.1			1.1	

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.

Tetracycline resistance was also low in 2020. The proportion of isolates resistant to erythromycin, gentamicin or streptomycin has remained low or non-existent throughout the monitoring period. Further, the percentage of isolates susceptible to all studied antibiotics has varied between 75% and 100%, with the lowest percentage in 2014 and 2018 paralleling the highest occurrence of quinolone resistance (Figure 11). In 2020, the proportion of resistant isolates dropped nine percentage points from the previous year. Multidrug resistance to the tested antibiotics has not been detected.

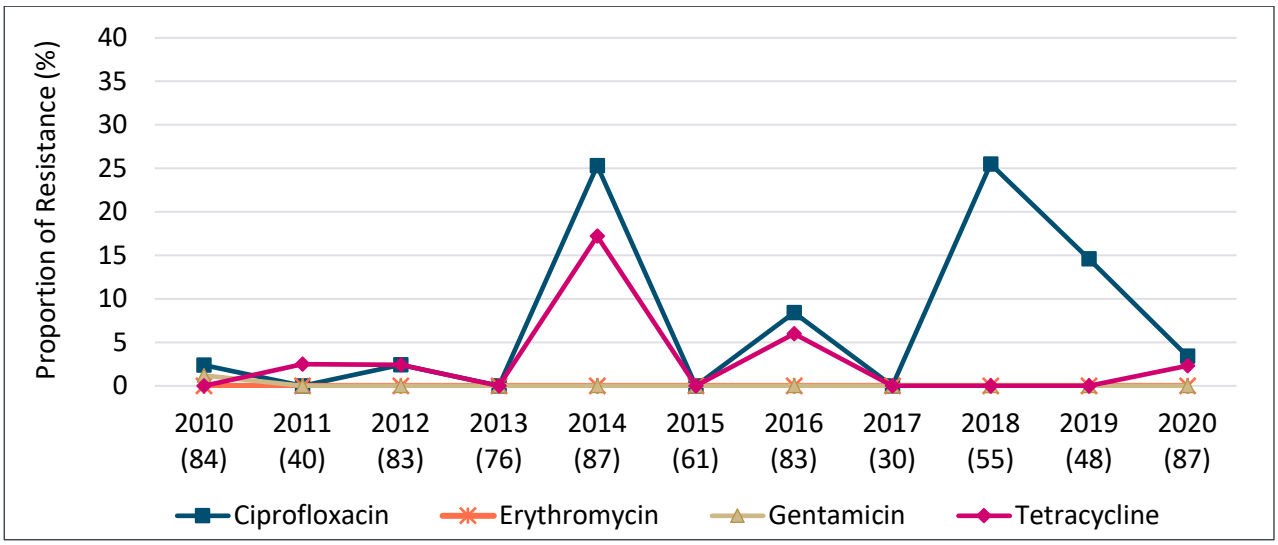

Figure 10*. The proportions of resistant Campylobacter jejuni isolates from broilers at slaughter in Finland between the years 2010 and 2020. The number of isolates tested each year are in brackets.*

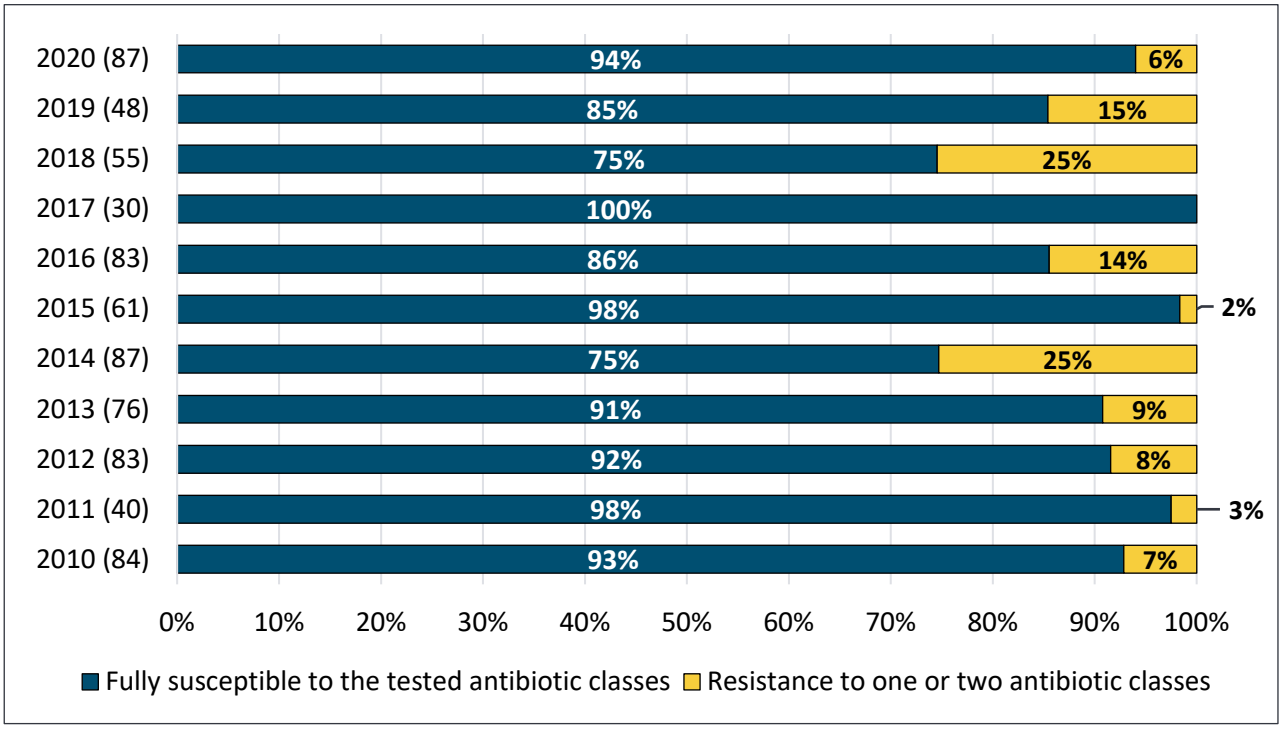

Figure 11. *Antibiotic susceptibility of Campylobacter jejuni isolated from broilers at slaughter in Finland between the years 2010 and 2020. The number of isolates tested each year are in brackets.*

2.2.2 *Campylobacter jejuni* from cattle

In 2020, 100 *C. jejuni* isolates from bovine faeces, collected at slaughter, were studied for antibiotic resistance. Of these, 29 were resistant to quinolones (ciprofloxacin and nalidixic acid), 12 to tetracycline and one to streptomycin (Table 5). No gentamicin or erythromycin resistance was detected.

Table 5. *Distribution of MICs for Campylobacter jejuni from cattle in 2020 (n=100).*

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	29.0	21.0–38.5	65.0	6.0					24.0	4.0	1.0			
Erythromycin	0.0	0.0–3.7				100								
Gentamicin	0.0	0.0–3.7		10.0	66.0	24.0								
Nalidixic acid	29.0	21.0–38.5					14.0	35.0	21.0	1.0		1.0	28.0	
Streptomycin	1.0	0.2–5.4			4.0	23.0	68.0	4.0			1.0			
Tetracycline	12.0	7.0–19.8			87.0	1.0			1.0	4.0	1.0	3.0	3.0	

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.

C. jejuni have been isolated in the FINRES-Vet monitoring programme from cattle every third or fourth year since 2003. Between 2003 and 2009, resistance has been low against the tested antibiotics (Figure 11). However, the proportion of quinolone resistant isolates has substantially increased in the 2010's. In 2020, in addition to fluoroquinolone resistance, the proportion of tetracycline resistant isolates increased also

almost 10 percentage points from the previous two screening years. Furthermore, one multidrug resistant isolate was detected (resistant to ciprofloxacin, nalidixic acid, streptomycin, and tetracycline) (Figure 12).

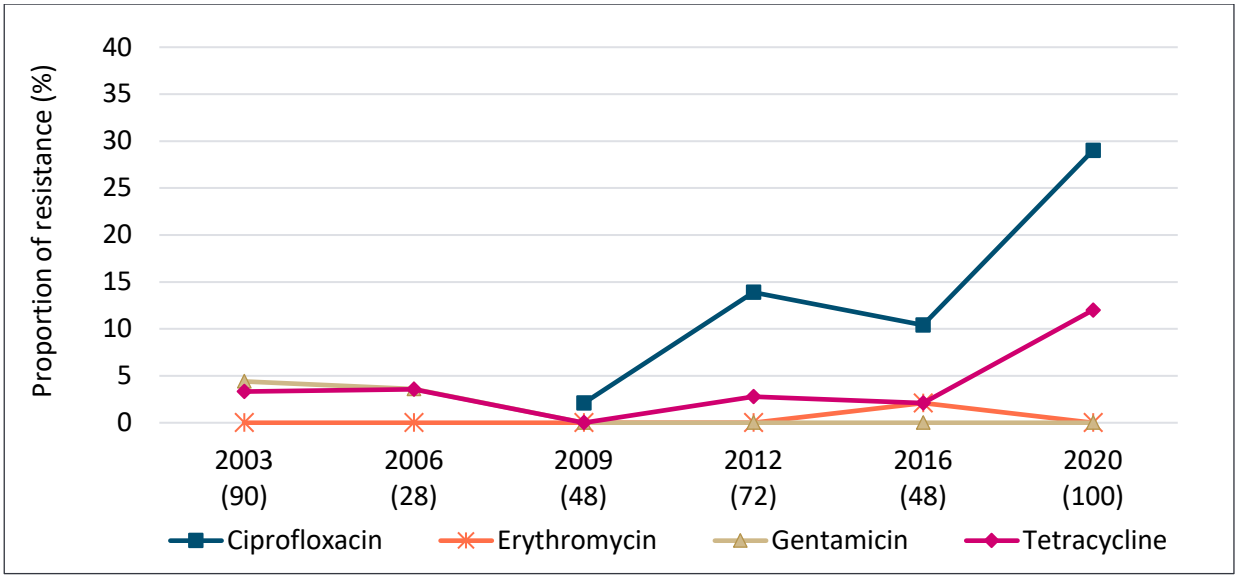

Figure 11. *Resistance in Campylobacter jejuni isolated from cattle at slaughter in Finland in 2003–2020. The number of isolates tested each year are in brackets.*

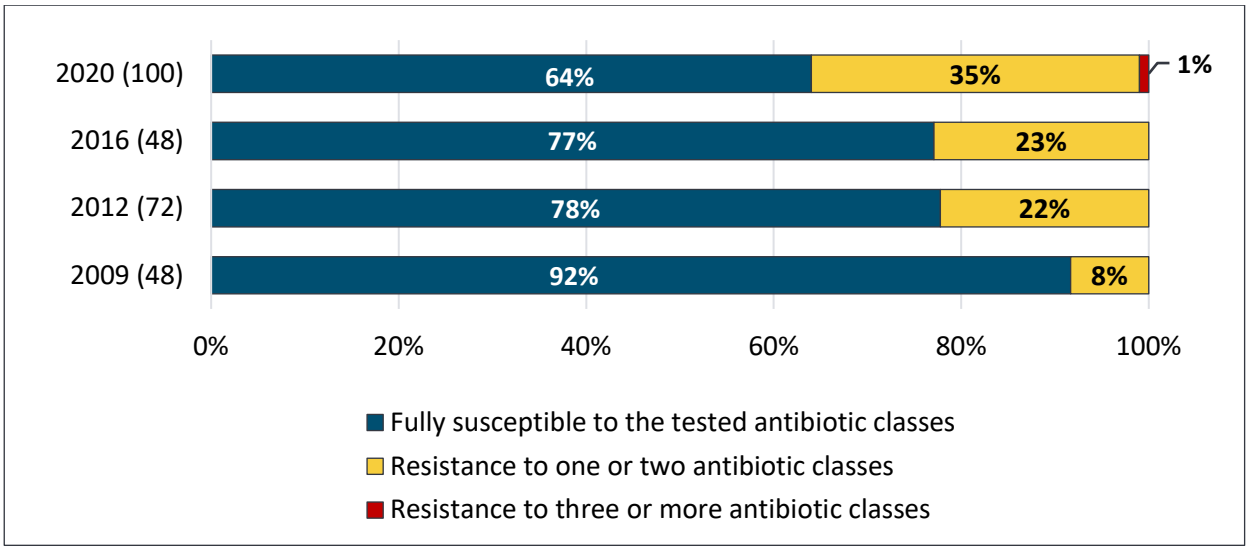

Figure 12. *Antibiotic susceptibility of Campylobacter jejuni isolated from bovines at slaughter in Finland between the years 2009 and 2020. The number of isolates tested each year are in brackets.*

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 (2013/652/EU). In Finland, these bacteria are screened from broilers, cattle, and pigs, as well as meat thereof, targeting broilers, cattle, and broiler meat in 2020. Additionally, liners from the transport boxes of imported broiler parental flocks and eggs, 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* from broilers, cattle, and meat from broilers

In 2020, extended-spectrum beta-lactamase (including AmpC beta-lactamase) producing *E. coli* were screened with selective isolation method from broiler caecal (n=309) and bovine faecal samples (n=295) collected at slaughterhouses as well as from broiler meat samples (n=296) collected at retail. In 2020, the prevalence of ESBL-producing *E. coli* was 0.3% both in broilers and in broiler meat and no AmpC-*E. coli* was detected (Table 6, Figure 13). In cattle, the prevalence of ESBL- or AmpC-producing *E. coli* was 3.1%, both enzyme types quite equally found (Table 6). Carbapenemase-producing *E. coli* was not detected in any of the samples.

Compared to the previous monitoring years 2016 and 2018, the prevalence of ESBL/AmpC-producing *E. coli* in broilers and broiler meat has decreased significantly (Table 6, Figure 13). Broiler meat samples have constantly been of domestic origin and the decreasing trend in broiler meat as well as in domestically produced broilers might at least partially be explained by the fact that ESBL/AmpC *E. coli* has been a rare finding in imported broiler flocks since 2018 (see also chapter 3.2).

ESBL/AmpC-producing *E. coli* in cattle were last monitored in 2016 when these bacteria were found in 1.3% of the samples. A slight increase in prevalence is therefore noted between 2016 and 2020.

Table 6. *Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing E. coli in food-producing animals and meat in 2016, 2018 and 2020.*

Year	Sampling stage	Nr of samples	Nr (%) of ESBL[1]	Nr (%) of AmpC[1]	Nr of CP-EC[2]	% ESBL/AmpC
Broilers						
2020	at slaughter	309	1 (0.3%)	0 (0%)	0	0.3%
2018	at slaughter	289	5 (1.7%)	33 (11.4%)	0	13.1%
2016	at slaughter	306	11 (3.6%)[3]	33 (11.1%)	0	14.4%
Cattle						
2020	at slaughter	295	4 (1.4%)	5 (1.7%)	0	3.1%
2016[4]	at slaughter	233	0 (0%)	3 (1.3%)	0	1.3%
Broiler meat						
2020	at retail	296	1 (0.3%)	0 (0%)	0	0.3%
2018	at retail	300	9 (3.0%)	37 (12.3%)	0	15.3%
2016	at retail	309	15 (4.9%)	53 (17.1%)	0	22.0%

[1] based on phenotypic characterization, see appendix 3. [2] CP-EC, carbapenemase-producing *Escherichia coli,* [3] one isolate had also cefoxitin MIC of 16 i.e. presumptive ESBL+AmpC, [4] CP-EC were screened from 204 samples.

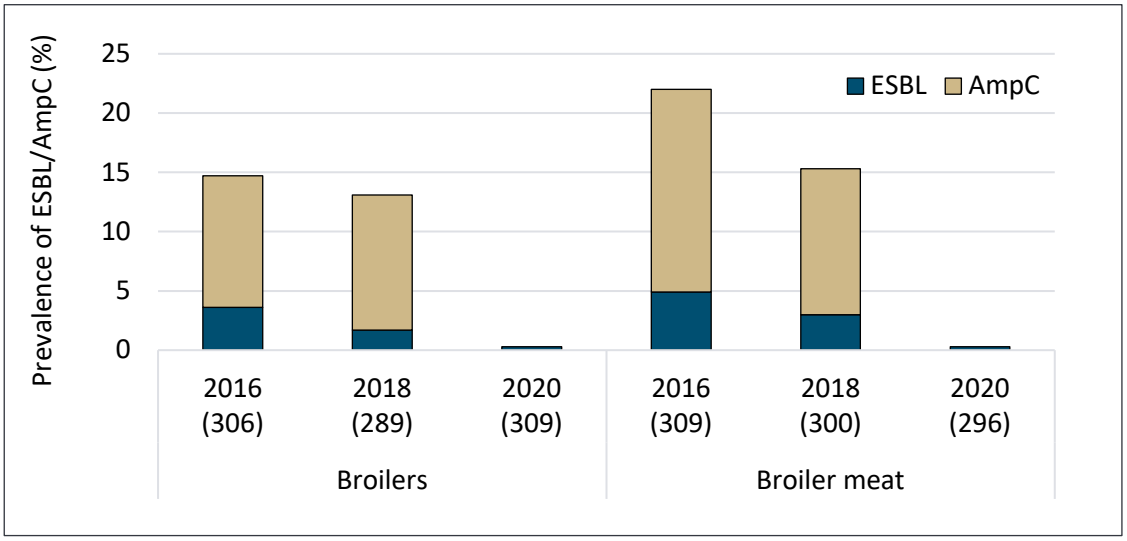

Figure 13. *Proportion of ESBL- and AmpC-producing E. coli in broilers and broiler meat in 2016, 2018 and 2020. The number of samples tested each year are in brackets.*

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

In 2020, liners of transport boxes of 34, four 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). This represents the majority of poultry flocks imported to Finland (see details in Appendix 3).

One ESBL-positive chicken flock was detected in 2020. Over the screening period of 2014–2020, ESBL/AmpC-producing *E. coli* have not been found in imported turkeys. However, the proportion of positive flocks has fluctuated between 0 to 39% for the imported broiler production chain, and between 0 to 75% for the chicken egg production chain. Carbapenemase-producing *E. coli* have not been detected. Between 2018 and 2020, ESBL/AmpC-producing *E. coli* were found only from one imported poultry flock and thus the situation is very favourable. The lack of ESBL/AmpC findings in broiler parental flocks in recent years is most likely reflected on the low prevalence of ESBL/AmpC-producing *E. coli* in slaughtered broilers and broiler meat samples taken at retail.

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 in 2014–2020.*

Imported poultry flocks	2014	2015	2016	2017	2018	2019	2020
For broiler meat production							
Nr of sampled flocks	37	54	62	37	42	38	34
Nr of ESBL positive flocks	1	1	0	0	0	0	0
Nr of AmpC positive flocks	3	9	24	8	0	0	0
Nr (%) of ESBL/AmpC positive flocks	4 (11%)	10 (19%)	24 (39%)	8 (22%)	0 (0%)	0 (0%)	0 (0%)
For turkey production							
Nr of sampled flocks	5	6	5	4	5	5	4
Nr of ESBL positive flocks	0	0	0	0	0	0	0
Nr of AmpC positive flocks	0	0	0	0	0	0	0
Nr (%) of ESBL/AmpC positive flocks	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
For egg production							
Nr of sampled flocks	6	4	3	4	5	3	5
Nr of ESBL positive flocks	1	1	0	0	0	0	0
Nr of AmpC positive flocks	3	2	0	3	0	0	1
Nr (%) of ESBL/AmpC positive flocks	4 (67%)	3 (75%)	0 (0%)	3 (75%)	0 (0%)	0 (0%)	1 (20%)

4 Antibiotic resistance in animal pathogens from food-producing animals

Animal pathogens isolated from food-producing animals included in this report are from swine, bovine, and broiler clinical cases. The reported pathogens from pigs are *E. coli* and *Brachyspira pilosicoli* from porcine enteritis, and *Actinobacillus pleuropneumoniae* from respiratory diseases. From bovines, the respiratory pathogens *Pasteurella multocida, Mannheimia haemolytica* and *Histophilus somni* are reported. From broilers, *E. coli* from colibacillosis, and *Staphylococcus aureus* from arthritis and tenosynovitis are reported. 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 post-mortem samples submitted to Finnish Food Authority. All isolates were confirmed by PCR to be enterotoxigenic. Altogether, 51 *E. coli* isolates from 28 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. Furthermore, at least part of the isolates is likely to originate from farms with diarrheal problems and higher than average antibiotic 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, as well as sulfamethoxazole, trimethoprim, and their combination. In 2020, resistance to chloramphenicol was low and no resistance to florfenicol was detected. Also, no resistance against colistin or gentamicin has been detected between 2016 and 2020 (Figure 14). Resistance against 3rd generation cephalosporins (according to the epidemiological cut-off values) was detected in 10 isolates from 5 farms, from which all were phenotypically AmpC. No ESBL-producers were found.

In 2020, the level of resistance was markedly higher than in previous years for most of the tested antibiotics, especially for streptomycin, sulfamethoxazole, trimethoprim, and their combination as well as for fluoroquinolones (Figure 14). Multidrug resistance was also at a higher level and at the same time the proportion of fully susceptible strains was smaller than in previous years (Figure 15).

The number of AmpC producers was also greater than ever before during the FINRES-Vet monitoring history. However, MIC values were overall quite low i.e. between 0.5 and 1 for cefotaxime, and between 0.5 and 4 for ceftazidime. One strain gave a MIC value of 4 for colistin but in genetic analyses, no known genetic mechanism for colistin resistance was detected. The true nature of this one strain still remains to be solved.

Whether this rise in resistance levels for several substances is due to low number of strains tested and is therefore just a matter of consequence or the resistance situation in pig farms truly is markedly worse than before, the results of the year 2020 are concerning. More attention should be paid on investigating the true resistance levels of *E. coli* causing porcine postweaning enteritis.

In summary, resistance was commonly detected to all antibiotic classes that can be used to treat *E. coli* infections in pigs (sulfonamide-trimethoprim, tetracycline, aminopenicillins and fluoroquinolones). Attention should be paid to the fact that enteritis in pigs can be caused by multidrug resistant *E. coli* bacteria. This emphasises the importance of diagnostic samples in order to determine the farm-specific resistance profiles of enterotoxigenic *E. coli*. To avoid further selection of antibiotic resistance, focus should be aimed to minimize the need for antibiotic treatments and only efficient drugs should be used in the treatment of *E. coli* diarrhoea in pigs.

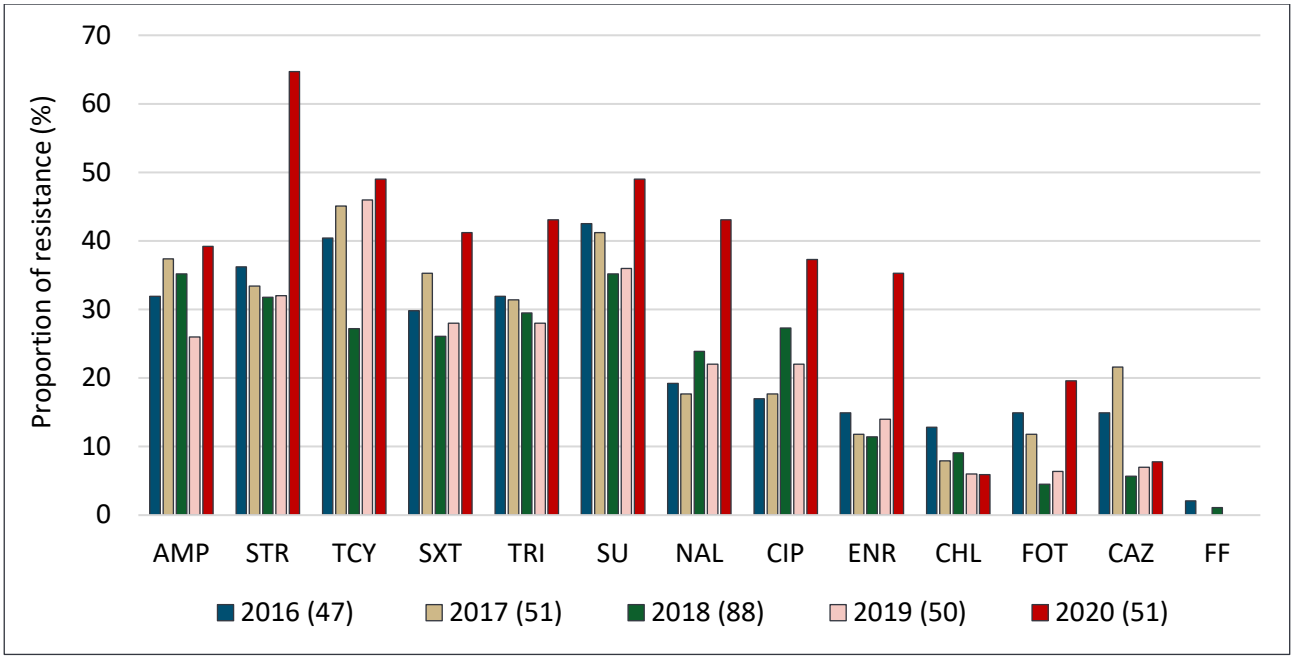

***Figure 14**. Resistance to tested antibiotics in 2016–2020, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

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

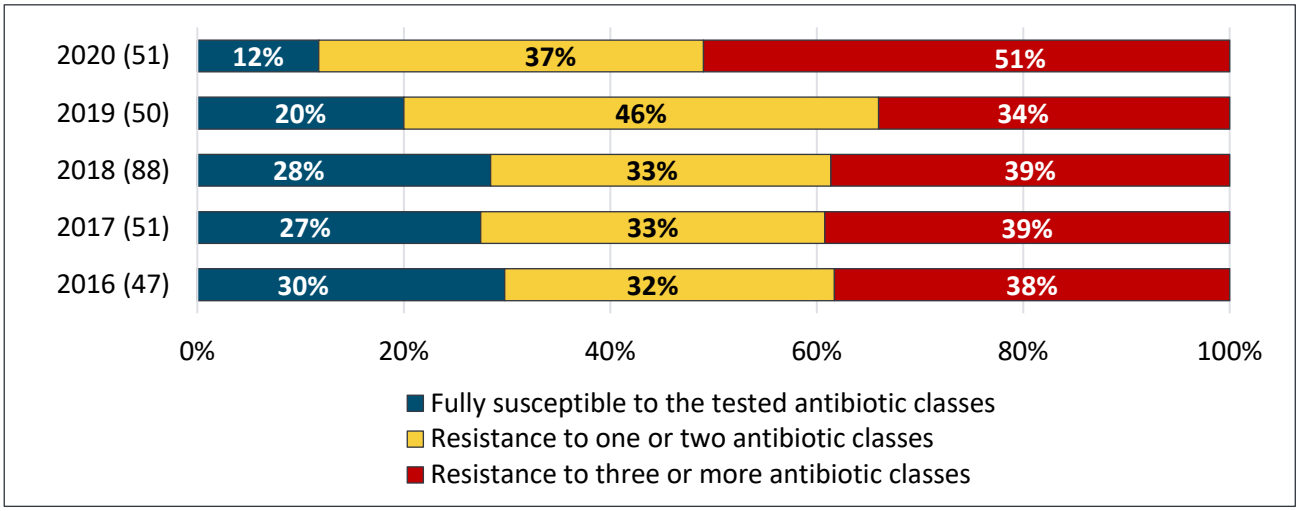

***Figure 15**. The proportions of multidrug resistant E. coli isolates from porcine enteritis in 2016–2020, epidemiological cut-off values used. The number of isolates tested each year are in brackets.*

Table 8. *Distribution of MICs for Escherichia coli from porcine enteritis in 2020 (n=51). Resistance percentage is the proportion of resistance calculated with 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	>1024
Ampicillin	39.2	15.9–39.6							3.9	35.3	15.7	5.9	3.9	13.7	21.6					
Cefotaxime	19.6	32.5–11.0			49.0	21.6	9.8	13.7	5.9											
Ceftazidime	7.8	18.5–3.1					72.5	19.6	2.0		5.9									
Chloramphenicol	5.9	15.9–2.0									66.7	27.5		2.0	3.9					
Ciprofloxacin	37.3	51.0–25.3	41.4	11.8	9.8	23.5	11.8				2.0									
Colistin	2.0	10.3–0.3							86.3	11.8		2.0								
Enrofloxacin	35.3	49.0–23.6			52.9	11.8	25.5	7.8			2.0									
Florfenicol	0.0	0.0-7.0									74.5	21.6	3.9							
Gentamicin	0.0	0.0-7.0						86.3	13.7											
Nalidixic acid	43.1	56.7–30.5									49.0	7.8	2.0	7.8	23.5	9.8				
Streptomycin	64.7	76.4–51.0									21.6	7.8	5.9	13.7	51.0					
Sulfamethoxazole[1]	49.0	62.3–35.9										51.0								49.0
Tetracycline	49.0	62.3–35.9							29.4	21.6			2.0	3.9	3.9	19.6	19.6			
Trimethoprim	43.1	56.7–30.5					45.1	9.8	2.0		2.0	2.0		39.2						
Trim/sulfa[2]	41.2	54.8–28.8						58.8			2.0	39.2								

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] No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (double vertical line) for resistance monitoring purposes. [2]concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20.

4.2 *Actinobacillus pleuropneumoniae* from respiratory diseases of pigs

A. pleuropneumoniae is the most important respiratory pathogen in growing pigs in Finland. In 2020, altogether 32 isolates from 25 farms were tested for antibiotic susceptibility. All obtained isolates were included. Clinical breakpoints (CLSI, 2018) were used to evaluate decreased susceptibility. 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 2020, no significant changes in the MICs for the tested substances can be seen. Each year the number of tested isolates is rather small.

Table 9. *Distribution of MICs for Actinobacillus pleuropneumoniae from pigs in 2020 (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		96.9		3.1							
Penicillin[1]	0.0	0.0-10.7	18.8	53.1	28.1								
Oxytetracycline	0.0	0.0-10.7			78.1	21.9							
Tiamulin	0.0	0.0-10.7			3.1				46.9	50.0			
Tulathromycin	0.0	0.0-10.7					3.1		9.4	56.3	31.3		

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 breakpoints not available, breakpoints for ampicillin used instead

4.3 *Brachyspira pilosicoli* from pigs

There are no standardised breakpoints established for *Brachyspira pilosicoli* from pigs. As a guide for the choice of antibiotic for treatment of spirochaetal diarrhoea, clinical breakpoints of >0.5 mg/L for tiamulin, >32 mg/L for tylosin, >4 mg/L for tylvalosin and >2 mg/L for lincomycin were used in Finland in 2020. With these breakpoints, 5% of the isolates were resistant to tiamulin, 24% to tylosin, 24% to lincomycin and 10 % to tylvalosin (Table 10). Resistance in *B. pilosicoli* has been at the same level from 2015 to 2019, although the number of isolates tested each year has been too small to draw any definite conclusions.

Table 10. *Distribution of MICs for Brachyspira pilosicoli from pigs in 2020 (n=21).*

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			81.0			4.8	14.3							
Lincomycin					71.4	4.8			4.8	14.3	4.8			
Tiamulin		52.4	19.0	19.0	4.8	4.8								
Tylosin							28.6	38.1	9.5			4.8	4.8	14.3
Tylvalosin					33.3	23.8	28.6	4.8	4.8			4.8		
Valnemulin	57.1	19.0	9.5	14.3										

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

One isolate per submission (and from each compartment if more than one was sampled) and per bacterial species was selected for susceptibility testing. Clinical breakpoints (CLSI, 2018) were used to evaluate decreased susceptibility. All tested isolates were susceptible to ceftiofur, tulathromycin and enrofloxacin.

Histophilus somni isolates resistant to oxytetracycline were found in one farm in 2020. Isolates obtained from 20 other farms were fully susceptible to the tested antibiotics. The MIC distributions of different antibiotics for *H. somni* are shown in Table 11. Between 2016 and 2020, decreased susceptibility has been detected only against oxytetracycline (from 7% to 11 %) but the resistant isolates have all originated from the same calf-rearing farm.

Table 11. *Distribution of MICs for Histophilus somni from bovine respiratory disease in 2020 (n=24).*

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	0.0-13.8		100									
Enrofloxacin	0.0	0.0-13.8	100										
Florfenicol	0.0	0.0-13.8		100									
Oxytetracycline	8.3	2.3-25.8			91.7					8.3			
Penicillin	0.0	0.0-13.8	100										
Tulathromycin	0.0	0.0-13.8				8.3	41.7	33.3	16.7				

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.

In 2020, *Pasteurella multocida* isolates were obtained from 131 farms and on 124/131 (95%) of these farms, isolates were fully susceptible. On one farm, *P. multocida* resistant to penicillin, oxytetracycline and intermediate susceptibility to florfenicol and on another farm isolate resistant to penicillin and oxytetracycline were found. Isolates resistant to only oxytetracycline were found on four farms. On one

farm, isolate resistant only to penicillin was seen. Since 2016, resistance has overall been low among *P. multocida* from bovine respiratory diseases (Figure 16). Resistance has most commonly been detected against oxytetracycline. The MIC distributions of different antibiotics for *P. multocida* isolated in 2020 are shown in Table 12.

Table 12. *Distribution of MICs for Pasteurella multocida from bovine respiratory disease in 2020 (n=221).*

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	0.0-1.7		100									
Enrofloxacin	0.0	0.0-1.7	100										
Florfenicol	0.0	0.0-1.7		59.7	37.6	2.3		0.5					
Oxytetracycline	3.2	1.5-6.4			79.2	5.0	12.2	0.5		3.2			
Penicillin	2.8	1.3-5.8	95.5	1.8					0.5	2.3			
Tulathromycin	0.0	0.0-1.7				51.1	35.3	11.3	2.3				

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.

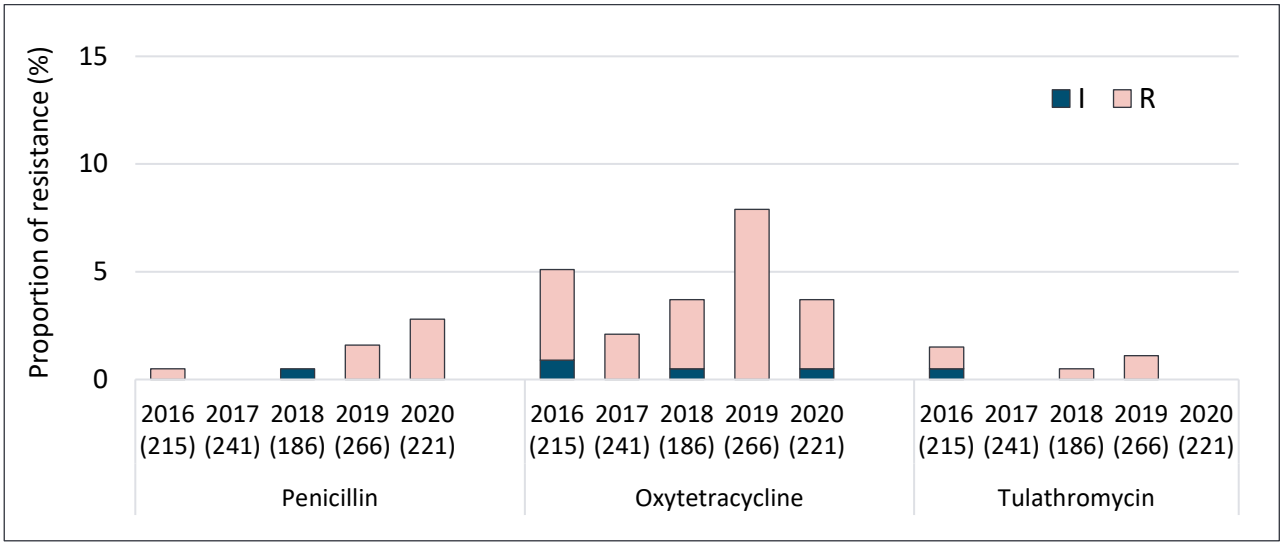

Figure 16. *The antibiotic non-susceptibility (%) of Pasteurella multocida from bovine respiratory disease in 2016–2020. The number of isolates tested each year are in brackets.*

In 2020, *Mannheimia haemolytica* isolates were obtained from 63 farms and on 48/63 (76%) of these farms, isolates were fully susceptible. An isolate resistant to both oxytetracycline and florfenicol was found on one farm and isolates resistant only to oxytetracycline were obtained from two other farms. Furthermore, on two farms, isolates resistant only to penicillin were found and on one farm isolates were either resistant or had intermediate susceptibility. Isolates from eight farms showed intermediate susceptibility to penicillin and isolates from one farm to oxytetracycline. Since 2016, resistance and intermediate susceptibility have most commonly been detected against penicillin (Figure 17). The MIC distributions of different antibiotics for *M. haemolytica* isolated in 2020 are shown in Table 13.

Table 13. *Distribution of MICs for Mannheimia haemolytica from bovine respiratory disease in 2020 (n=71).*

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	0.0-5.1		100									
Enrofloxacin	0.0	0.0-5.1	100										
Florfenicol	1.4	0.2-7.6		2.8	21.1	74.6				1.4			
Oxytetracycline	4.2	1.4-11.7			60.6	32.4	1.4	1.4		4.2			
Penicillin	5.6	2.2-13.6	42.3	39.4	12.7	2.8				2.8			
Tulathromycin	0.0	0.0-5.1					28.2	70.4	1.4				

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.

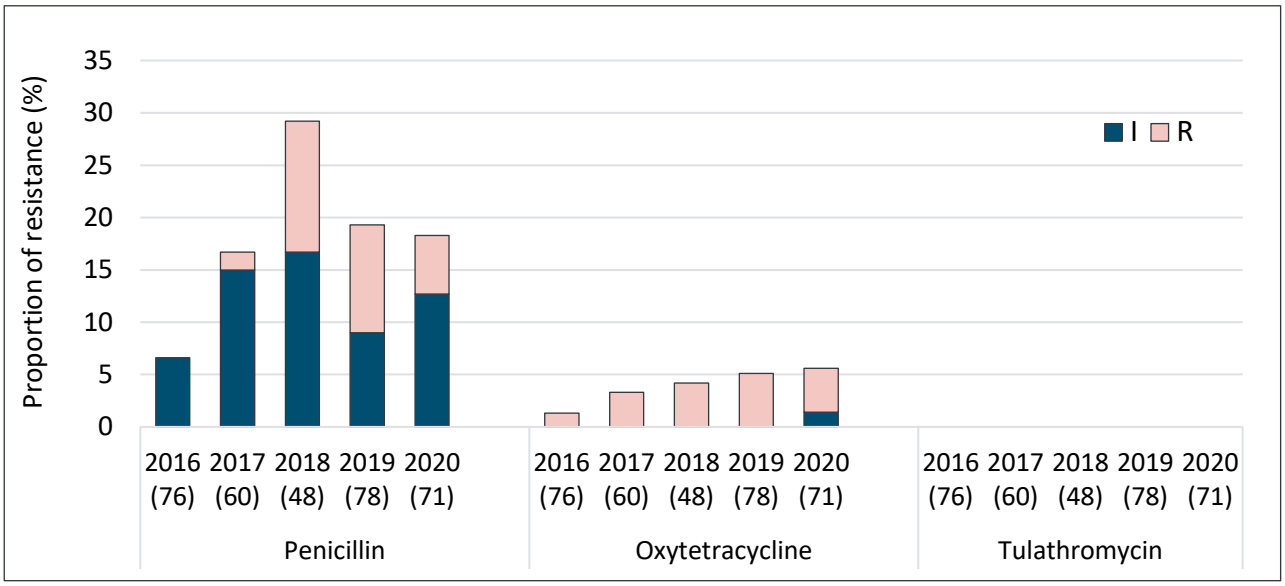

Figure 17. *The antibiotic non-susceptibility (%) of M. haemolytica from bovine respiratory disease in 2016–2020. The number of isolates tested each year are in brackets.*

4.5 *Escherichia coli* from colibacillosis in broilers

Colibacillosis infections in broilers or broiler parents are not treated with antibiotics in Finland. In 2020, colibacillosis was not a major problem in broiler production and the number of strains isolated and tested was rather small. In 2020, 16 isolates representing 15 different flocks were studied. Based on epidemiological cut-off values, resistance to ampicillin, sulfamethoxazole and tetracycline was somewhat higher than in previous years. Only single isolates resistant against 3rd generation cephalosporins were found in 2016 and 2017 but not at all in 2018–2020. The occurrence of resistance against different antibiotics has varied annually from zero to moderate levels (Figure 18) which is probably due to a small number of tested isolates. The MIC distributions of different antibiotics for are shown in Table 14.

Table 14. *Distribution of MICs for Escherichia coli from colibacillosis in 2020 (n=16).*

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	>1024
Ampicillin	12.5	2.9-40.2								31.3	56.3				12.5					
Cefotaxime	0.0	0.0-24.3			75.0	25.0														
Ceftazidime	0.0	0.0-24.3					93.8	6.3												
Ciprofloxacin	0.0	0.0-24.3	75.0	25.0																
Colistin	0.0	0.0-24.3							81.3	18.8										
Sulfamethoxazole[1]	25.0	8.9-53.2										68.8	6.3					6.3	6.3	12.5
Tetracycline	25.0	8.9-53.2							6.3	62.5	6.3				18.8	6.3				
Trimethoprim	6.3	0.9-32.8					43.8	50.0						6.3						

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]No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (double vertical line) for resistance monitoring purposes.

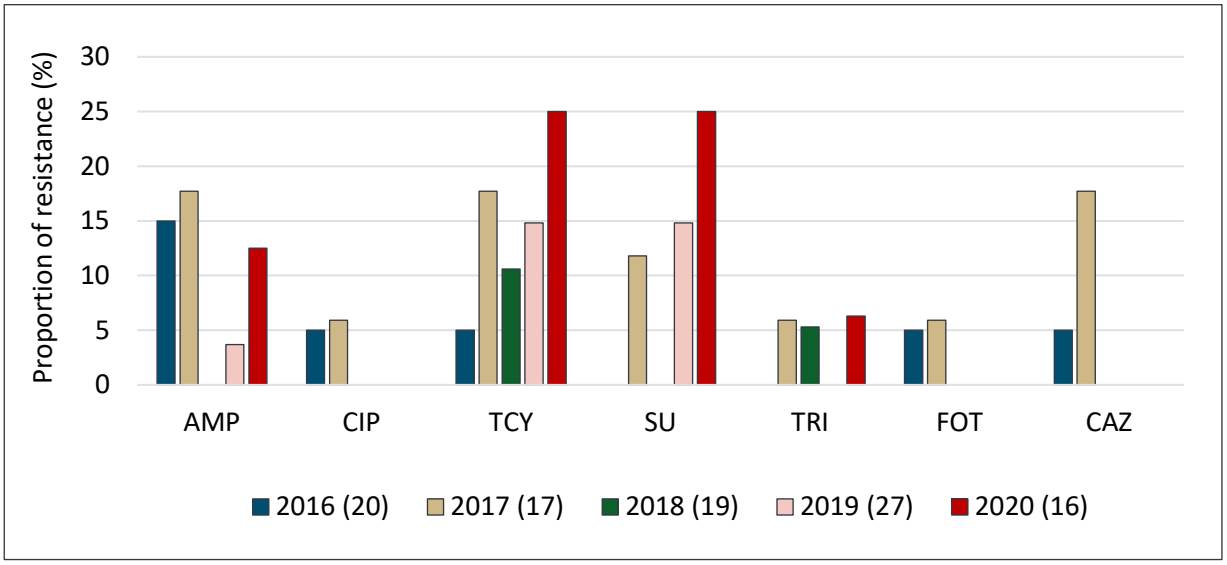

***Figure 18**. Antibiotic resistance (%) in E. coli from colibacillosis in the years 2016–2020, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

AMP, ampicillin; CIP, ciprofloxacin, TCY; tetracycline; SU, sulfamethoxazole; TRI, trimethoprim, FOT, cefotaxime; CAZ, ceftazidime.

4.6 *Staphylococcus aureus* from tenosynovitis in broilers

Staphylococcus aureus from broiler tenosynovitis cases were isolated from post-mortem samples submitted to Finnish Food Authority. All obtained *S. aureus* isolates were included. Sixteen isolates from thirteen different flocks and farms were studied. All isolates were susceptible to the reported antibiotics (Table 15). None of the isolates were beta-lactamase producers or MRSA. Tenosynovitis is occasionally treated with antibiotics in broiler parent flocks but only a small number of flocks are treated. Production flocks have not been treated with antibiotics since 2010 (Animal Health ETT, 2021).

***Table 15.** Distribution of MICs for Staphylococcus aureus from tenosynovitis in broilers in 2020 (n=16).*

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	0.0-19.4								100				
Penicillin[1]	0.0	0.0-19.4	81.3	18.8										
Tetracycline	0.0	0.0-19.4					100							
Trim/sulfa[2]	0.0	0.0-19.4			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 based on beta-lactamase production, [2]Concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20

5 Antibiotic resistance in animal pathogens from companion animals and horses

Antibiotic resistance figures from companion animal (dogs and cats) and horse pathogens were collected from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. In this context, antibiotic resistance corresponds to the proportion of resistant and intermediate isolates. The reporting period covers January 2014–December 2020 and includes solely bacterial isolates derived from clinical infections. Screening specimens for multiresistant bacteria (MRSA, MRSP, ESBL) were omitted from the analysis. Approximately 39% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 61% from private clinics. If the number of tested bacterial isolates for the bacterial species in question was large enough for confident analysis, 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

Antibiotic resistance in *S. aureus* from dogs, cats and horses was low (Figure 19), except for penicillin (not shown in figure). In 2020, 69% of the *S. aureus* isolates produced penicillinase, having been 67–68% in 2018–2019.

Oxacillin resistance (indicating the presence of MRSA among *S. aureus* isolates) during the monitoring period remained generally at a low level, ranging from 0–9%, and being approximately 7% in 2020. Of the eight MRSA isolates detected in clinical infections in 2020, two isolates were from dogs and six from horses. One of the canine isolates was of *spa* type t011, the other was not investigated further. During 2020, an outbreak of MRSA CC398 (*spa* t011) was still ongoing in the Equine Teaching Hospital of the University of Helsinki. While there were many cases of nosocomial colonisation, only single infections were noted.

S. aureus is a part of the normal microbiome of the skin and mucous membranes of cats and horses, as well as of humans. As an opportunistic pathogen, it usually causes skin or wound infections in animals. Occasionally, there can be infections caused by *S. aureus* also in dogs.

MRSA is considered to be a zoonotic bacterium and may thus have an impact on public health. While most clinical findings were from dogs, the large-scale nosocomial spread of the bacterium among horses is of concern. The horse stable environment may not provide horse owners, caregivers, and hobbyists the necessary tools to prevent the zoonotic spread of MRSA.

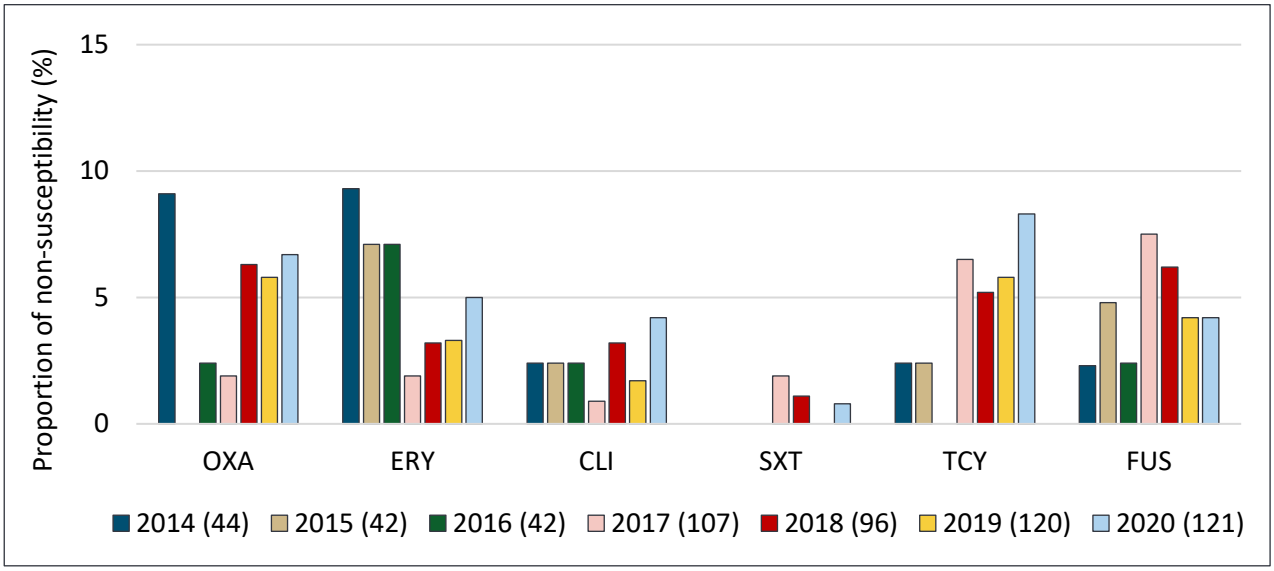

***Figure 19**. Antibiotic non-susceptibility (%) in canine, feline, and equine S. aureus in 2014–2020. The number of isolates tested each year are in brackets.*
OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline; FUS, fusidic acid.

5.2 *Staphylococcus pseudintermedius* from dogs

The proportion of MRSP isolates, indicated by oxacillin non-susceptibility, decreased by nearly three %-points from 2019 (4.5% in 2020). The resistance level has declined drastically in four years: in 2016, the proportion of MRSP was as high as 13.6% of all *S. pseudintermedius* isolates (Figure 20). Penicillinase production remained high as out of the 665 tested *S. pseudintermedius* isolates in 2020, 84% produced penicillinase, which is a larger proportion than among *S. aureus* isolates ($p<0.0001$).

The overall resistance level of *S. pseudintermedius* remained similar in 2020 compared to the few previous years (Figures 20 and 21). Macrolide (erythromycin) and lincosamide (clindamycin) non-susceptibility remained at the same level compared to the year 2019, having been approximately 21% for both antibiotic classes. The highest proportion of non-susceptible isolates throughout the whole monitoring period was noted for tetracyclines. Tetracycline and doxycycline resistance levels were both at approximately 27%.

No resistance to amikacin was detected in clinical infection isolates of *S. pseudintermedius* in 2020.

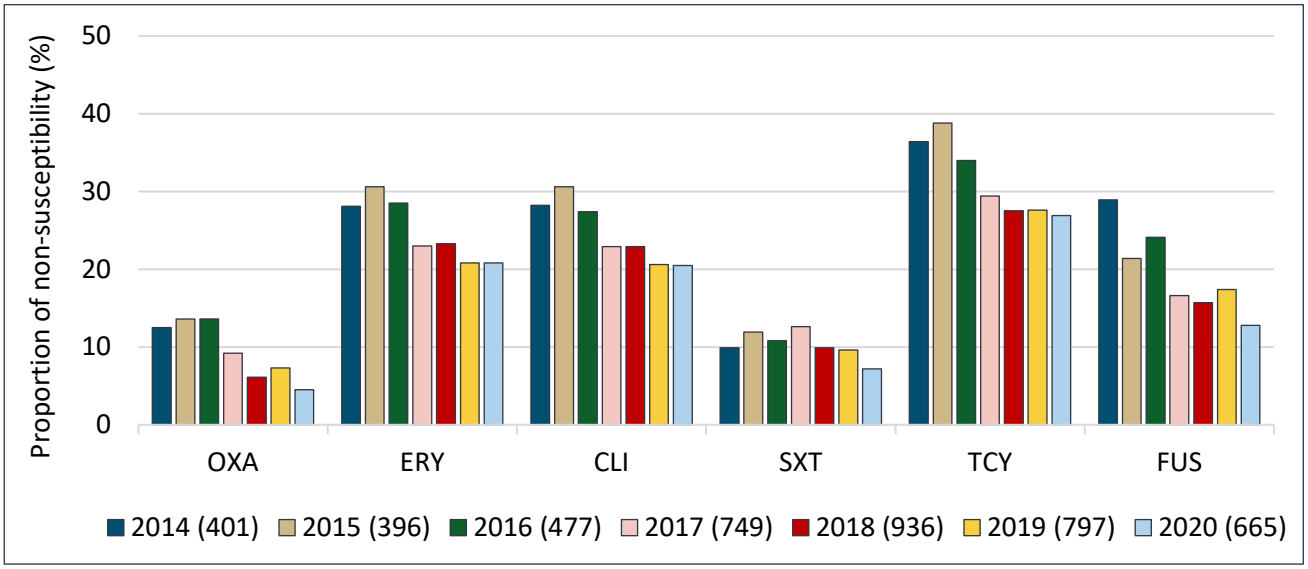

***Figure 20**. Antibiotic non-susceptibility (%) for primary antibiotics in canine S. pseudintermedius isolates in 2014–2020. The number of isolates tested each year are in brackets.*

OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline; FUS, fusidic acid

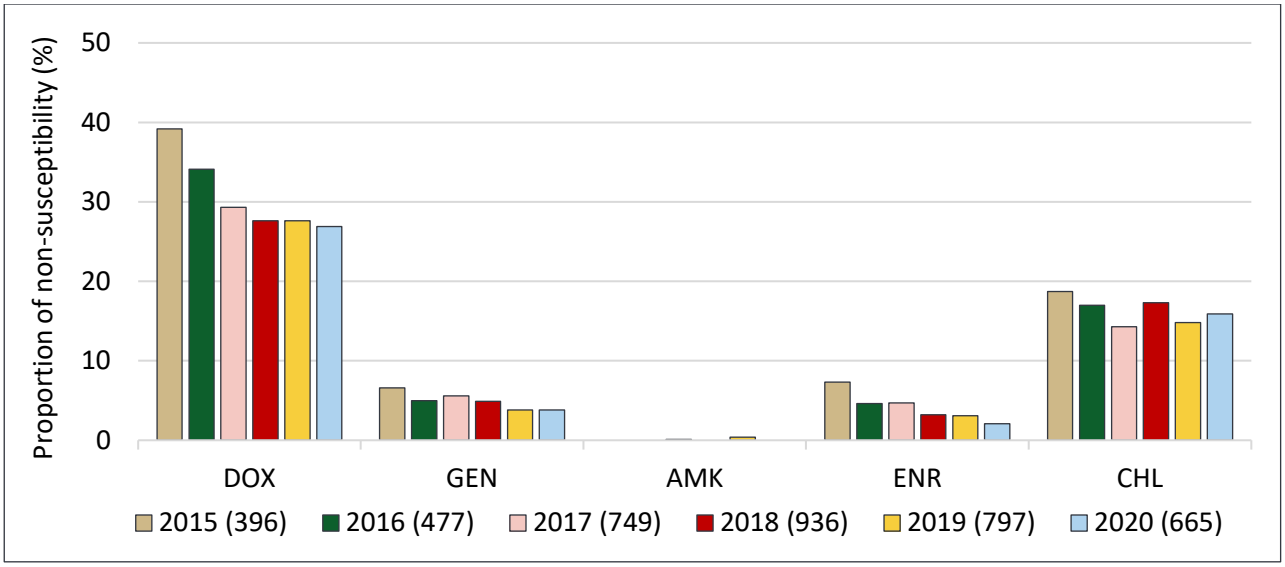

***Figure 21**. Antibiotic non-susceptibility (%) for secondary antibiotics in canine S. pseudintermedius isolates in 2015–2020. The number of isolates tested each year are in brackets. The year 2014 was omitted due to small number of tested isolates.*

DOX, doxycycline; GEN, gentamicin; AMK, amikacin; ENR, enrofloxacin; CHL, chloramphenicol

S. pseudintermedius belongs to the normal microbiome of the skin and mucous membranes in dogs and more rarely in cats. It is an opportunistic pathogen that most often causes skin or wound infections and occasionally urinary infections. Many of the infections caused by *S. pseudintermedius* can be treated locally and thus the use of antibiotics can be avoided altogether.

As stated earlier, 84% of the isolates produced penicillinase, which is a major proportion. A penicillinase-producing isolate is resistant to many commonly used beta-lactam antibiotics, such as ampicillin,

amoxicillin, and penicillin. Since a majority of *S. pseudintermedius* isolates produce penicillinase, knowing this might affect the empirical choice of antibiotic in treating for example sporadic cystitis in a dog, if a coccal species is suspected to have caused the infection. *S. pseudintermedius* is a moderately common urinary pathogen in dogs.

5.3 *Escherichia coli* from dogs and cats

Resistance figures for canine and feline *E. coli* are presented in Figures 22 and 23, respectively. While ampicillin non-susceptibility decreased in canine *E. coli*, a slight increase in amoxicillin-clavulanic acid non-susceptibility was observed. It may be that the year 2018 was a statistical anomaly as no other explanation for a sudden drop in non-susceptibility level of ampicillin was identified. In feline isolates, ampicillin resistance remained similar to previous years. Amoxicillin-clavulanic acid non-susceptibility was analogous for both cats and dogs.

Enrofloxacin resistance in canine *E. coli* isolates persisted on a similar level than in previous years, having been roughly 6% in 2020. Sulfonamide-trimethoprim resistance in canine and feline *E. coli* fluctuated through the monitoring period and was 12% in dogs and 4% in cats in 2020.

In 2020, 4.8% of canine *E. coli* were resistant to cefpodoxime, indicating reduced susceptibility to third generation cephalosporins (Figures 22 and 24). The proportion AmpC producing isolates increased slightly in 2020, having been 3.3%, whereas in 2019 the corresponding number was 2.7%. However, the proportion of ESBL remained below 1% (0.5% in 2020, 0.9% in 2019) (Figure 24). In 2020, the proportion of isolates resistant to cefpodoxime in feline *E. coli* persisted at the same level as in 2019 (4.8% in 2020, 5.1% in 2019).

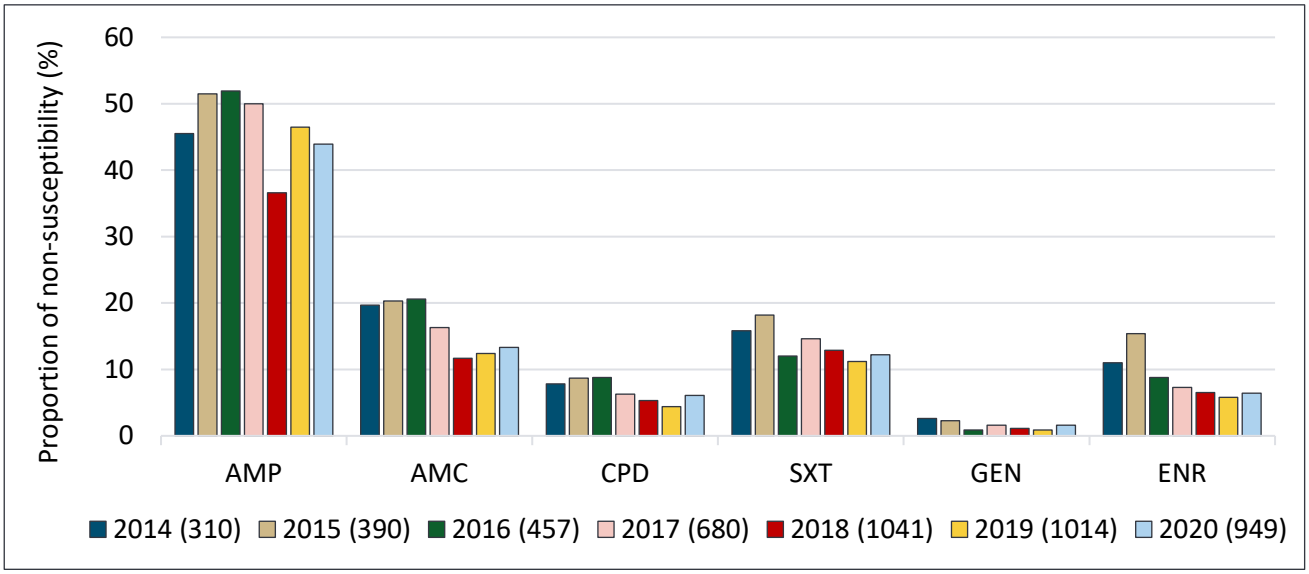

***Figure 22**. Antibiotic non-susceptibility (%) in canine E. coli in 2014–2020. The number of isolates tested each year are in brackets.*

AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; SXT, trimethoprim-sulfamethoxazole; GEN, gentamicin; ENR, enrofloxacin

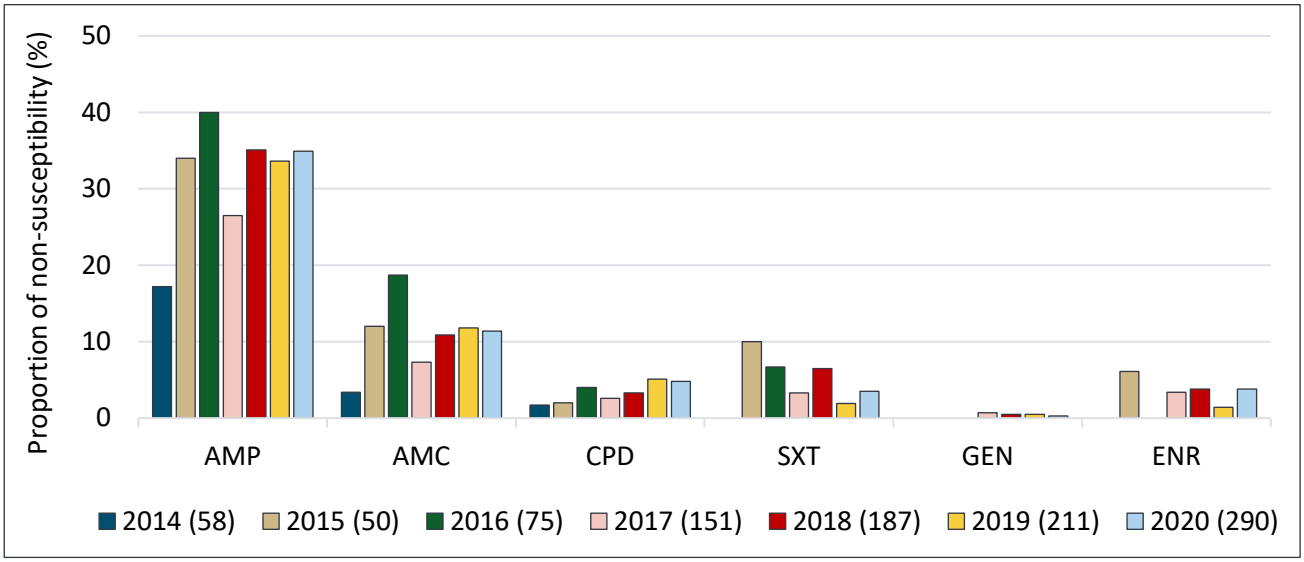

***Figure 23**. Antibiotic non-susceptibility (%) in feline E. coli in 2014–2020. The number of isolates tested each year are in brackets.*

AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; SXT, trimethoprim-sulfamethoxazole; GEN, gentamicin; ENR, enrofloxacin

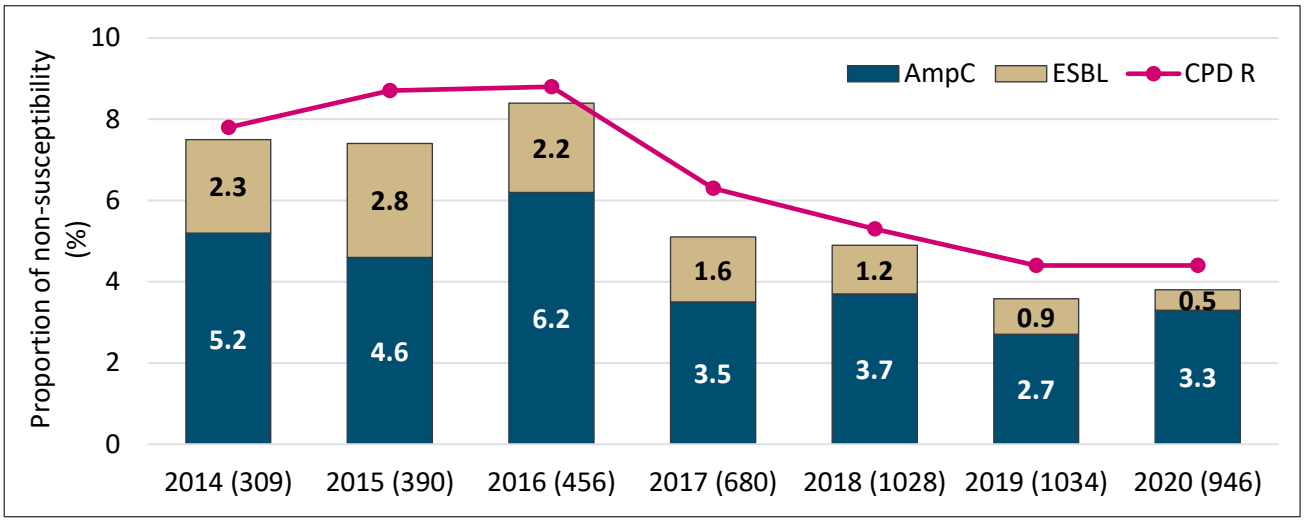

***Figure 24.** The proportion of isolates with reduced susceptibility to cefpodoxime (CPD), and the proportion of ESBL and AmpC positive isolates in canine E. coli in 2014–2020. The number of isolates tested for CPD each year are in brackets. Only CPD resistant isolates were tested for phenotypic ESBL/AmpC production.*

CPD, cefpodoxime; AmpC and ESBL, extended-spectrum beta-lactamases

5.4 Streptococci from dogs and horses

In 2020, all of the tested canine *Streptococcus canis* isolates (210) were susceptible to penicillin and trimethoprim-sulfamethoxazole (Figure 25). Macrolide (erythromycin) and tetracycline (tetracycline, clindamycin) non-susceptibility decreased slightly. It is worth noting that from the beginning of 2019 *S. canis* isolates from otitis externa specimens were not tested for systemic antibiotics (e.g. penicillin,

trimethoprim-sulfamethoxazole, erythromycin, and clindamycin). Thus, the number of tested isolates for tetracycline has been larger ever since.

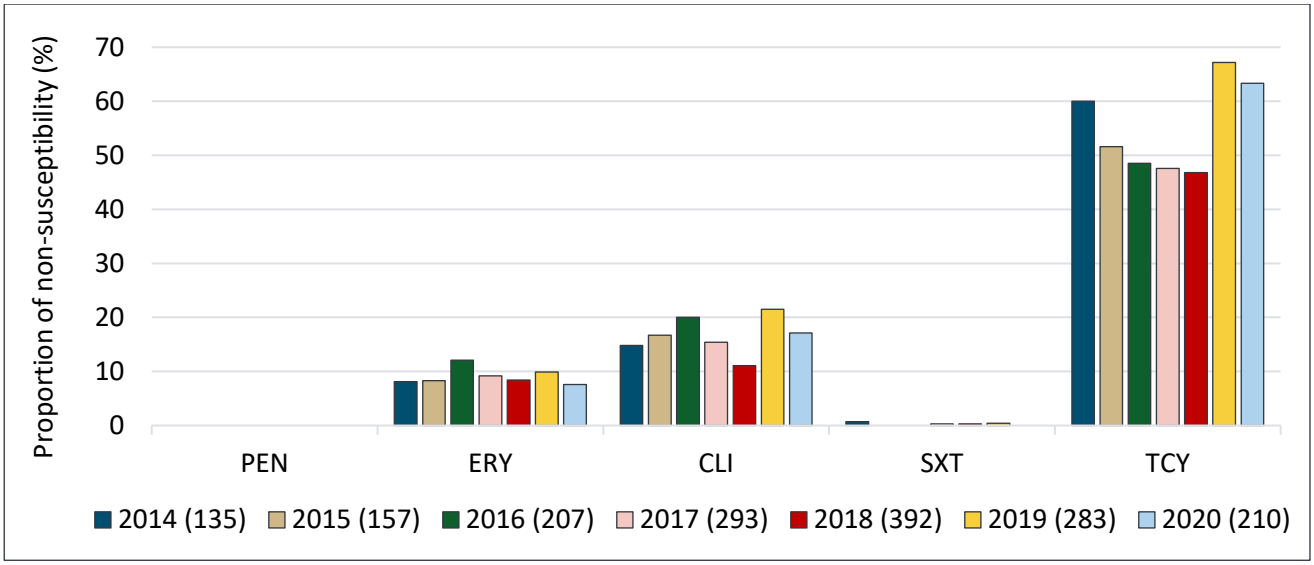

***Figure 25**. Antibiotic non-susceptibility (%) in canine S. canis isolates in 2014–2020. The number of isolates tested each year are in brackets (in 2019, 351 isolates and in 2020, 258 isolates were tested for tetracycline susceptibility).*

PEN, penicillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline

In 2020, only 26 equine *Streptococcus equi* ssp. *zooepidemicus* isolates were found in clinical infection specimens. All of the isolates were susceptible to penicillin (Figure 26). Trimethoprim-sulfamethoxazole resistance remained low (4% in 2020), however, the development of resistance to this antibiotic still has to be monitored carefully due to the importance of it in the treatment of many equine infections.

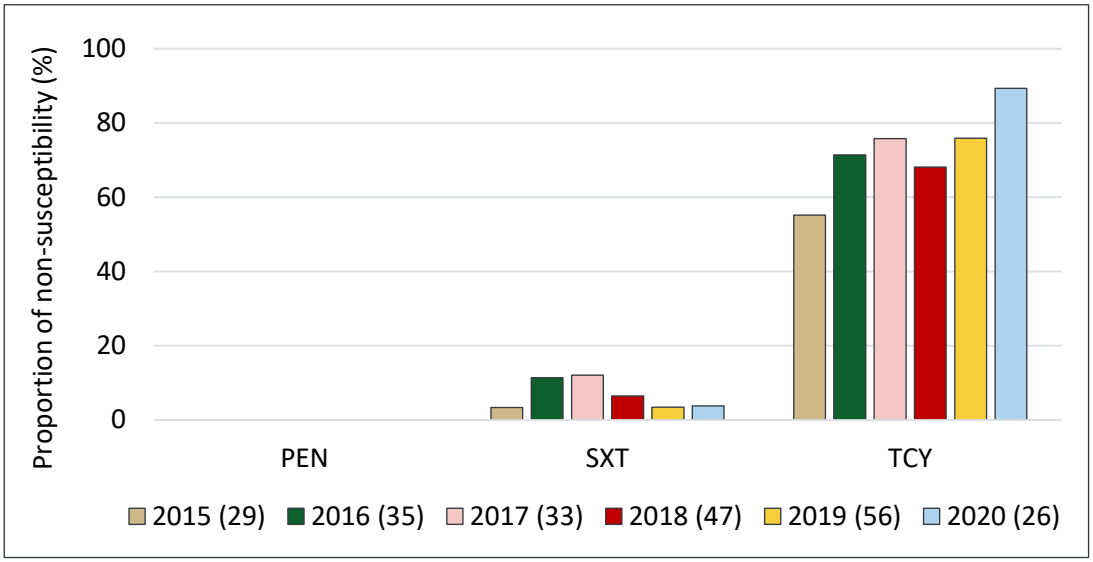

***Figure 26**. Antibiotic non-susceptibility (%) in equine S. equi* ssp. *zooepidemicus isolates in 2015–2020. The number of isolates tested each year are in brackets. Year 2014 was omitted due to small number of tested isolates.*

PEN, penicillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline

5.5 *Pseudomonas aeruginosa* from dogs

In 2020, 88 canine clinical infection isolates of *Pseudomonas aeruginosa* were tested. Overall, the isolates were quite susceptible to all tested antibiotics, as noted in previous years (Figure 27). Roughly 3% of the isolates expressed amikacin non-susceptibility. Gentamicin resistance level remained on the same level than in 2019. No resistance to polymyxin B or tobramycin was detected. Most of the isolates (94%) were susceptible to ciprofloxacin. For enrofloxacin, 24% of the isolates were classified as resistant (74% non-susceptible).

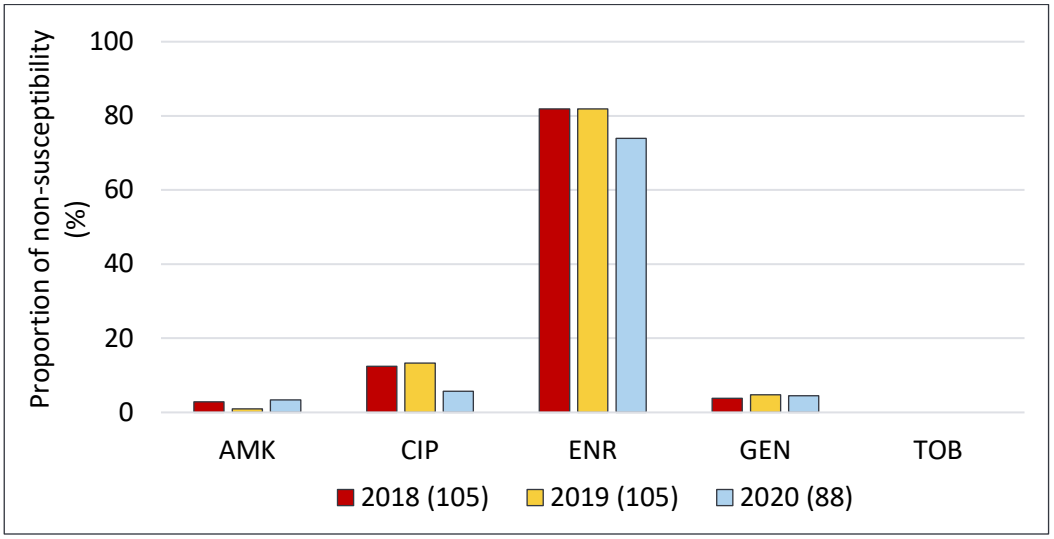

Figure 27. *Antibiotic non-susceptibility (%) in canine P. aeruginosa isolates in 2018–2020. The number of isolates tested each year are in brackets.*
AK, amikacin; CIP, ciprofloxacin; ENR, enrofloxacin; GEN, gentamicin; TOB, tobramycin

6 Antibiotic resistance in indicator bacteria from food-producing animals

Resistance in commensal indicator *E. coli* is thought to show the most common resistance traits among the gram-negative bacteria present in the gut microbiota, and to reflect the selection pressure caused by the antibiotics used in the animal population in question. In this report, the results of the indicator *E. coli* from slaughtered, healthy broilers and cattle are presented. Details of the sampling and laboratory analysis are described in Appendix 3.

6.1 Indicator *E. coli* from broilers

In 2020, a total of 170 isolates from broilers were tested for antibiotic susceptibility. Resistance was overall low (Table 16) and the majority (83%) of the isolates was fully susceptible to the tested antibiotics (Figure 29). The most common resistance traits detected were against tetracycline (9%), ciprofloxacin (5%), nalidixic acid (5%), ampicillin (4%), and sulfamethoxazole (4%) (Table 16). Altogether, 2.4% of the isolates were multidrug resistant. ESBL or AmpC isolates were not detected.

Resistance levels have been quite stable over the last twelve years (Figure 28). The proportion of resistant isolates to ampicillin increased from 4% to 14% between the years 2011 and 2018 but in 2020, the resistance level dropped to 4%. Ciprofloxacin resistance has been around 5% since 2014. The proportion of tetracycline resistant isolates increased somewhat from 2018 and was in 2020 in a similar level as in 2016.

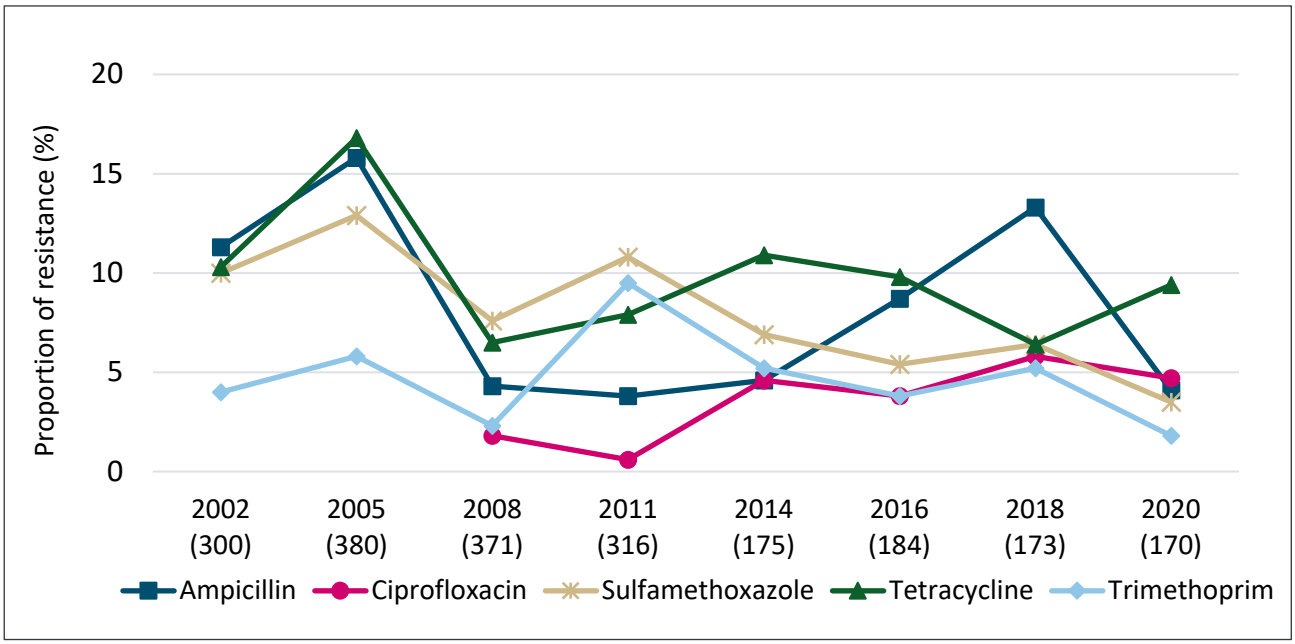

***Figure 28**. Resistance in indicator E. coli from broilers to selected antibiotics in 2002–2020. The number of isolates tested each year are in brackets.*

Table 16. *Distribution of MICs for indicator Escherichia coli in broilers in 2020 (n=170).*

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	>1024
Ampicillin	4.1	2.0–8.3							1.8	40.0	48.8	5.3				4.1				
Azithromycin[1]	0.0	0.0–2.2								0.6	46.5	46.5	6.5							
Cefotaxime	0.0	0.0–2.2					100													
Ceftazidime	0.0	0.0–2.2						100												
Chloramphenicol	0.0	0.0–2.2										98.8	1.2							
Ciprofloxacin	4.7	2.4–9.0	90.0	5.3		1.8	2.4		0.6											
Colistin	0.0	0.0–2.2							75.9	24.1										
Gentamicin	0.6	0.1–3.3						72.4	26.5	0.6				0.6						
Meropenem	0.0	0.0–2.2		100																
Nalidixic acid	4.7	2.4–9.0									95.3				2.9	0.6	1.2			
Sulfamethoxazole[2]	3.5	1.6–7.5										70.0	22.9	3.5						3.5
Tetracycline	9.4	5.9–14.7								88.2	2.4				5.3	4.1				
Tigecycline	0.0	0.0–2.2					98.2	1.8												
Trimethoprim	1.8	0.6–5.1					55.9	41.2	0.6	0.6					1.8					

Bold vertical lines indicate current (1.7.2021) EUCAST epidemiological cut-off (ECOFF) 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]A tentative EUCAST ECOFF. [2]No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (dashed vertical line) for resistance monitoring purposes.

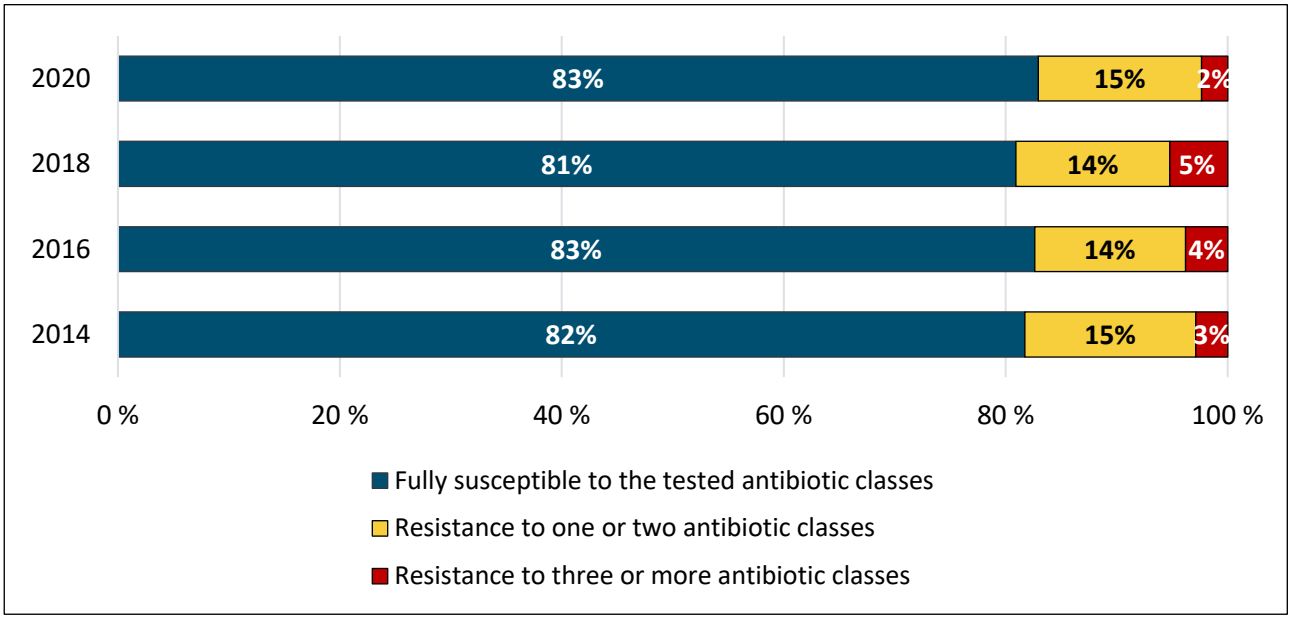

***Figure 29**. Antibiotic susceptibility of indicator E. coli from broilers at slaughter in Finland between the years 2014 and 2020. The numbers of tested isolates each year are the same as in Figure 28.*

***Table 17**. Resistance profiles of multidrug resistant indicator E. coli from broilers in 2014, 2016, 2018 and 2020.*

Resistance profile	Nr of isolates in each year			
	2014	2016	2018	2020
AMP-CAZ-CIP-FOT-NAL-SU-TET-TRI		1[1]		
TET-SU-TRI-CIP-NAL-GEN-CHL			1	
AMP-TET-SU-TRI-CIP-NAL			1	
AMP-SU-TRI-CIP-NAL		1		
AMP-SU-CIP-NAL		1	3	1
AMP-TET-SU-TRI		1	3	
AMP-CIP-NAL-TET				1
TET-SU-TRI	5	3		1
AMP-SU-TRI			1	1
Sum	**5**	**7**	**9**	**4**

AMP, Ampicillin; CAZ, ceftazidime; CHL, chloramphenicol; CIP, ciprofloxacin; FOT, cefotaxime; GEN, gentamicin; NAL, nalidixic acid; SU, sulfamethoxazole; TET, tetracycline; TRI, trimethoprim. [1] Phenotypically AmpC

6.2 Indicator *E. coli* from cattle

A total of 189 isolates from cattle were tested for antibiotic susceptibility in 2020. Resistance was not common (Table 18) and almost all (97%) of the isolates was fully susceptible to the tested antibiotics (Figure 31). Resistance was detected only against tetracycline (2%), sulfamethoxazole (2%), ampicillin (1%),

cefotaxime (<1%) and ceftazidime (<1%) (Table 16). Resistant isolates were resistant to only one or two antibiotic classes in 2020. One isolate showed an AmpC phenotype.

The proportion of resistant indicator *E. coli* isolated from cattle has in general been very low in Finland between 2003 and 2020 (Figure 30).

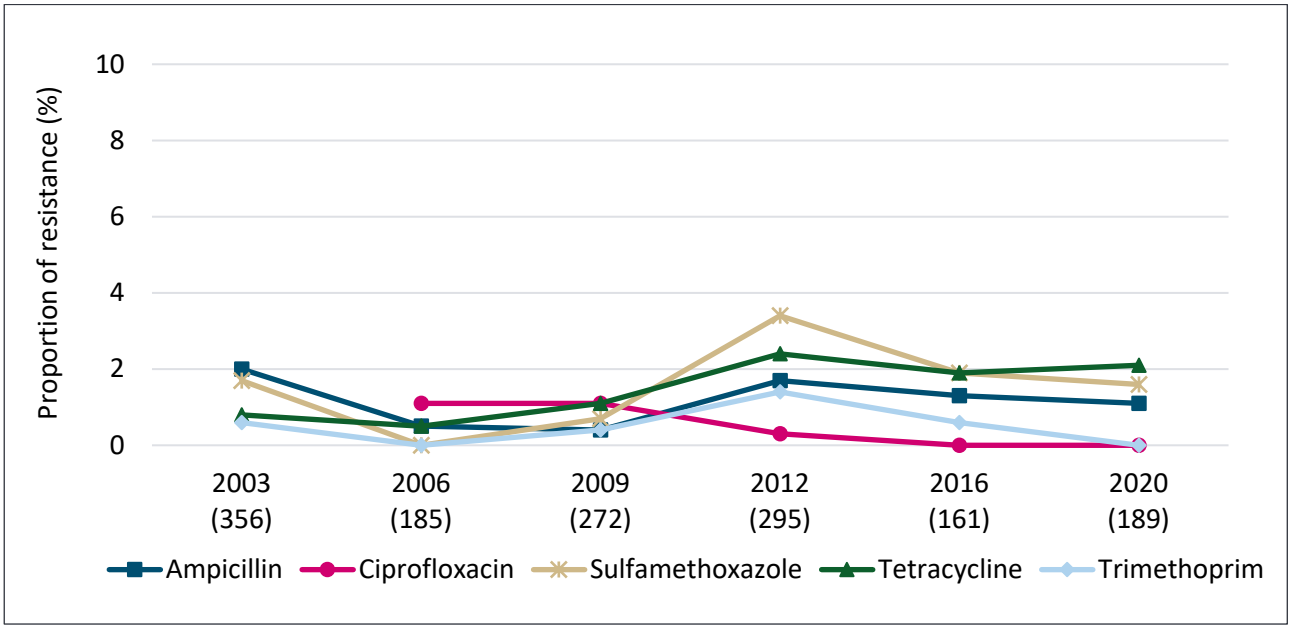

***Figure 30**. Resistance in indicator E. coli from cattle to selected antibiotics in 2003–2020. The number of isolates tested each year are in brackets.*

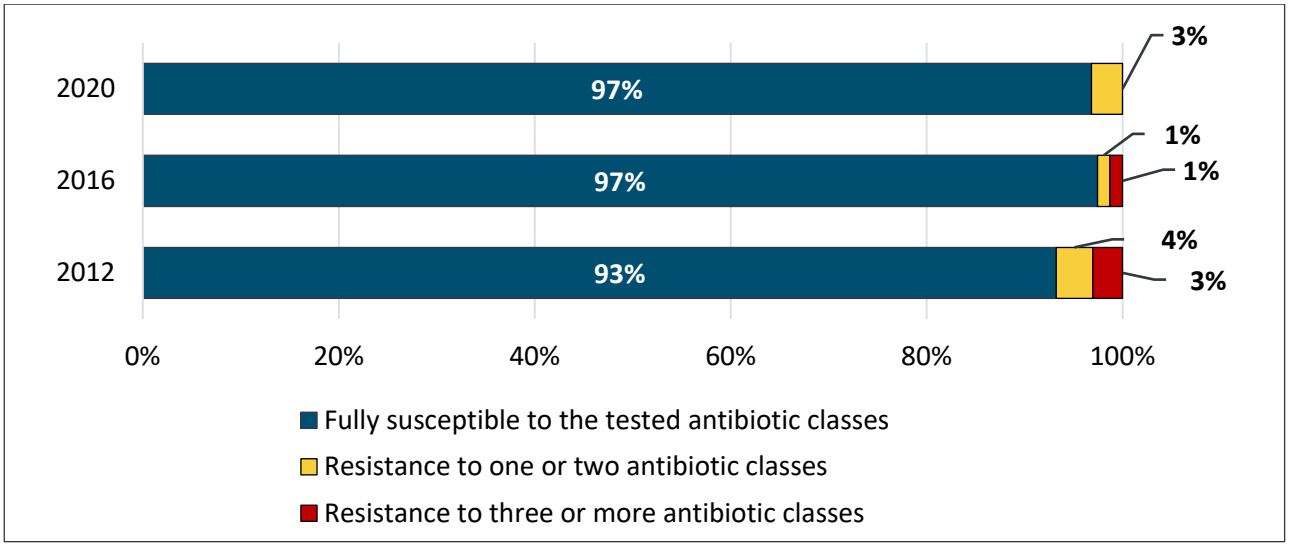

***Figure 31**. Antibiotic susceptibility of indicator E. coli from cattle at slaughter in Finland in 2012, 2016 and 2020. The numbers of tested isolates each year are the same as in Figure 30.*

Table 18. *Distribution of MICs for indicator Escherichia coli in cattle in 2020 (n=189).*

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	>1024
Ampicillin	1.1	0.3–3.8							4.2	27.5	56.6	10.6				1.1				
Azithromycin[1]	0.0	0.0–2.0								2.1	32.8	59.8	5.3							
Cefotaxime	0.5	0.1–2.9					99.5			0.5										
Ceftazidime	0.5	0.1–2.9						99.5			0.5									
Chloramphenicol	0.0	0.0–2.0										97.9	2.1							
Ciprofloxacin	0.0	0.0–2.0	89.9	10.1																
Colistin	0.0	0.0–2.0							82.0	18.0										
Gentamicin	0.0	0.0–2.0						81.5	18.0	0.5										
Meropenem	0.0	0.0–2.0		100																
Nalidixic acid	0.0	0.0–2.0									98.4	1.6								
Sulfamethoxazole[2]	1.6	0.5–4.6										84.1	13.8	0.5						1.6
Tetracycline	2.1	0.8–5.3								97.4	0.5					2.1				
Tigecycline	0.0	0.0–2.0					100													
Trimethoprim	0.0	0.0–2.0					64.6	32.8	2.1	0.5										

Bold vertical lines indicate current (1.7.2021) EUCAST epidemiological cut-off (ECOFF) 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]A tentative EUCAST ECOFF. [2]No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (dashed vertical line) for resistance monitoring purposes.

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Appendix 1. Population statistics

The population of food-producing animals (as PCU) is presented in Table 19. The number of livestock and farms, and the production of meat and milk in Finland are presented in Tables 20–23 (Source: Luke, the Natural Resources Institute Finland).

***Table 19**. Population of food-producing animals as PCU (1000 tonnes) by species in 2010–2020.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cattle	227	227	224	224	226	229	228	222	220	213	207
Pigs	182	182	171	170	163	163	161	153	142	142	145
Poultry	60	62	65	67	68	70	73	76	82	83	85
Sheep and goats	10	11	11	11	11	13	13	13	13	12	12
Horses	30	30	30	30	30	30	30	30	30	30	30
Fish	12	11	13	14	13	15	14	15	14	15	12
TOTAL, PCU	520	522	514	516	512	520	520	508	500	496	494

***Table 20.** Number of livestock (in thousands) in Finland in 2010–2020.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dairy cows	289	286	284	283	285	285	282	275	271	262	260
Suckler cows	55	57	58	57	58	59	59	60	60	60	62
Cattle > 1 year[1]	278	273	268	271	268	264	258	261	252	247	235
Calves < 1 year	303	299	303	300	303	307	310	297	299	288	290
TOTAL, Cattle	926	914	913	912	914	915	909	893	882	858	846
Boars and sows	154	146	136	128	123	NA	NA	NA	NA	NA	NA
Pigs > 20 kg	804	797	779	815	760	NA	NA	NA	NA	NA	NA
Piglets < 20 kg	409	392	375	365	362	NA	NA	NA	NA	NA	NA
TOTAL, pigs	1 367	1 335	1 290	1 308	1 245	1 243	1 235	1 136	1 089	1 072	1 087
Laying hens	3 394	3 304	3 173	3 432	3 645	3 595	3 599	3 746	3 985	3 900	3 812
Chicks	838	745	743	858	714	662	748	509	608	647	566
Broilers	4 616	5 421	6 038	6 861	7 341	7 827	8 272	8 047	8 781	9 112	8 507
Turkeys	280	308	295	274	292	246	260	292	299	263	268
Other poultry[2]	459	457	512	555	584	597	566	543	468	438	424
TOTAL, poultry	9 587	10 236	10 761	11 981	12 577	12 927	13 445	13 136	14 140	14 360	13 577

[1] Heifers and bulls in total. [2] Including broiler parent hens, cockerels, ducks, geese, guinea fowls, ostriches, ranched ducks and pheasants. 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 21. *Number of farms in Finland in 2010–2020.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cattle farms	15 641	14 919	14 141	13 416	12 885	12 389	11 791	11 175	10 530	9 851	9 301
Pig farms	2 078	1 917	1 747	1 637	1 486	1 337	1 240	1 102	1 027	963	918
Poultry farms	1 304	1 314	1 155	1 207	1 299	1 310	1 300	1 280	1 243	1 172	1 201

Source: OFS: Luke, Number of livestock.

Table 22*. The production of meat and fish (million kg) in Finland in 2010–2020.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beef[1]	83	84	81	81	83	86	87	86	87	88	87
Pork[1]	203	202	193	195	186	192	190	182	169	171	176
Poultry[1]	96	102	107	111	113	117	125	129	135	139	145
Total	383	387	382	387	383	397	403	397	391	398	408
Fish[2]	12	11	13	14	13	15	14	15	14	15	15

[1] In slaughterhouses. The production of beef and pork corrected according to the latest statistics. [2] for human consumption, ungutted. Source: OFS: Luke, Meat production and Aquaculture.

Table 23. *The production of milk in Finland in 2010–2020.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Milk production; per animal (litres)	7 896	7 859	7 876	7 977	8 201	8 323	8 406	8 534	8 650	8 810	9 038
Total milk production (million litres)	2 268	2 234	2 230	2 260	2 330	2 365	2 359	2 336	2 328	2 305	2 336

Source: OFS: Luke, Milk and milk products statistics.

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

Table 24. *Overall sales of veterinary antibiotics in Finland in 2010–2020, kg active ingredient.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tetracyclines	1 728	1 838	1 759	2 389	2 576	2 250	2 010	2 268	2 218	2 677	1 830
Amphenicols	59	124	61	121	84	80	87	104	112	117	109
Penicillin G[1]	4 852	4 709	4 504	4 442	4 231	4 058	3 544	3 771	3 805	3 705	3 824
Aminopenicillins	1 317	1 284	1 342	1 314	1 374	1 498	1 438	1 160	1 020	1 011	934
Cloxacillin	114	112	97	82	91	65	63	45	39	33	39
1st gen. cephalosporins	906	1056	902	793	753	605	513	355	284	227	184
3rd gen. cephalosporins	5	9	15	8	8	7	3	1	0.5	0.2	0.2
Sulfonamides and trimethoprim	3 274	3 045	3 149	3 129	2 893	2 445	2 460	2 216	1 870	2 119	1 646
Macrolides	572	532	575	456	521	596	517	408	411	221	192
Lincosamides	202	164	179	155	189	165	120	297	184	197	61
Aminoglycosides	166	128	108	103	101	93	87	73	61	59	42
Fluoroquinolones	96	102	107	105	113	94	99	80	81	66	70
Pleuromutilins	48	73	66	43	44	30	23	14	10	3	2
Total sales[1]	**13 342**	**13 174**	**12 864**	**13 140**	**12 979**	**11 987**	**10 964**	**10 790**	**10 095**	**10 435**	**8 932**

[1]Conversion factors for penicillins updated based on ESVAC 2021 protocol. Affects sales of penicillin G and total sales.

Table 25. *Sales of injectable veterinary antibiotics in Finland in 2010–2020, kg active ingredient.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tetracyclines	527	515	521	558	552	640	686	671	642	741	644
Amphenicols	0	12	13	26	17	6	13	26	15	23	24
Penicillin G[1]	4 722	4 557	4 279	4 270	3 981	3 781	3 230	3 538	3 564	3 479	3 565
Aminopenicillins	440	404	434	379	416	473	453	338	286	279	229
1st gen. cephalosporins	0	0	0	0	0	0	5	1	1	0	0
3rd gen. cephalosporins	5	9	15	8	8	7	3	1	0,5	0,2	0,2
Sulfonamides and trimethoprim	329	297	360	344	358	373	322	317	286	292	252
Macrolides	13	13	11	12	12	15	19	13	10	9	9
Lincosamides	40	30	27	24	26	26	25	19	18	19	24
Aminoglycosides	19	18	20	12	15	13	14	12	10	10	12
Fluoroquinolones	78	85	84	83	90	72	78	63	66	50	56
Total sales of injectables[1]	**6 171**	**5 938**	**5 763**	**5 718**	**5 475**	**5 406**	**4 849**	**4 999**	**4 899**	**4 902**	**4 815**

[1]Conversion factors for penicillins updated based on ESVAC 2021 protocol. Affects sales of penicillin G and total sales.

***Table 26**. Sales of orally administered veterinary antibiotics (premixes, oral solutions, oral powders, oral pastes, and tablets) in Finland in 2010–2020, kg active ingredient*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tetracyclines	1 202	1 323	1 237	1 830	2 024	1 610	1 324	1 597	1 575	1 936	1 186
Amphenicols	59	112	48	95	67	74	74	78	97	94	85
Penicillin G	0	17	110	47	122	147	190	100	105	94	118
Aminopenicillins	856	860	893	923	947	1 017	976	813	728	728	700
1st gen. cephalosporins	872	1 025	871	766	730	587	493	341	274	219	182
Sulfonamides and trimethoprim	2 945	2 747	2 789	2 784	2 535	2 072	2 138	1 899	1 584	1 828	1 394
Macrolides	559	519	565	444	510	581	498	395	402	212	183
Lincosamides	161	134	152	130	164	139	94	278	165	178	37
Aminoglycosides	95	79	76	76	70	62	54	41	32	29	8
Fluoroquinolones	19	17	23	22	22	22	22	16	15	15	14
Pleuromutilines	48	73	66	43	44	30	23	14	10	3	2
Imidazole derivatives	-	-	-	-	-	-	-	-	-	-	0
Total sales of orally adm. products	**6 816**	**6 906**	**6 829**	**7 160**	**7 236**	**6 342**	**5 885**	**5 571**	**4 986**	**5 338**	**3 909**

***Table 27.** Sales of intramammaries for veterinary use in Finland in 2010–2020, kg active ingredient*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Intramammaries for lactation phase											
Penicillin[1]	98	100	88	88	93	88	80	86	91	87	93
Aminopenicillins	15	14	11	8	8	7	7	6	5	3	4
Cephalexin	29	30	31	27	22	18	15	13	9	8	2
Cloxacillin	60	56	47	39	41	31	29	19	18	15	25
Aminoglycosides	29	12	1	0	0	0	0	0	0	0	0
Macrolides	1	1	0	0	0	0	0	0	0	0	0
Total lactation phase[1]	**230**	**213**	**178**	**162**	**164**	**144**	**131**	**123**	**123**	**113**	**124**
Intramammaries for dry cow treatment											
Penicillin[1]	33	36	27	37	35	41	44	47	45	45	49
Aminopenicillins	6	6	5	4	3	2	2	3	1	0	14
Cephalexin	6	1	0	0	0	0	0	0	0	0	0
Cloxacillin	55	55	49	43	50	35	34	26	21	18	14
Aminoglycosides	24	20	12	16	15	18	19	20	20	20	21
Total dry cow[1]	**124**	**117**	**93**	**100**	**104**	**96**	**100**	**97**	**87**	**83**	**85**

[1]Conversion factors for penicillins have been updated in accordance with ESVAC 2021 protocol. Affects sales of penicillin and total sales of intramammaries for dry cow treatment.

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 by the industry in association with the Finnish Campylobacter control programme for broilers. Samples were taken from healthy animals at the slaughterhouses covering approximately 99% of all broilers slaughtered in Finland. 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. From each epidemiological unit (slaughter batch), a caecal sample was taken from one animal. All isolates (one isolate per slaughter batch) were included in the antibiotic susceptibility testing.

Campylobacter jejuni from cattle were isolated between February and December from healthy animals at slaughter from the biggest slaughterhouses that accounted for approximately 92% of all cattle slaughtered in Finland. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. However, due to COVID-19 pandemic, sampling was suspended from the beginning of April until the end of May 2020. From each epidemiological unit (slaughter batch), faecal sample was taken from one animal. If several samples from the same epidemiological unit was taken, only one sample was taken for further analysis. The samples were taken aseptically and transported refrigerated to the laboratory within two days. Samples were collected between Monday and Thursday. One campylobacter isolate from each epidemiological unit (if available) was selected for susceptibility testing.

Animal pathogens

Clinical isolates originated from diagnostic submissions or post-mortem examinations done in the laboratories of Finnish Food Authority. *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 Finnish Food Authority. All obtained *S. aureus* isolates were included from the study period. *A. pleuropneumoniae* isolates originated 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 were from post-mortem samples from parent or production pedigree, and isolated either from bone marrow or heart. *Brachyspira pilosicoli* isolates were from faecal samples of swine with diarrhoea.

Antibiotic 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 2014-2020.

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

Indicator *E. coli* was isolated from broiler caeca and cattle faeces in 2020. From the same samples, the ESBL/AmpC and carbapenemase producing *E. coli* were screened. The samples from broilers (n=309) and cattle (n=295) originated from healthy animals at slaughter between February and December. However, due to COVID-19 pandemic, sampling was suspended from the beginning of April until the end of May 2020. Adjustments to the sampling plans of the EFSA mandatory resistance monitoring were made in the autumn 2020 so that the target number of 300 samples would be achieved in the specific monitoring of extended-spectrum beta-lactamase producing *E. coli*. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. The broiler slaughterhouses accounted approximately for 99% and the cattle slaughterhouses approximately 92% of the total number of slaughtered broilers and cattle in Finland, respectively. From each epidemiological unit (slaughter batch), a sample was taken from one animal. The samples were taken aseptically and transported refrigerated to the laboratory within two days. Samples were collected between Monday and Thursday. Indicator *E. coli* isolates from cattle were randomly selected for susceptibility from all isolates available at the laboratory. Indicator *E. coli* isolates from broilers were otherwise randomly selected for susceptibility testing except for February and March when all obtained isolates were included due to lower number of samples collected. All presumptive ESBL/AmpC/carbapenemase producing *E. coli* were tested for antibiotic susceptibility.

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

ESBL/AmpC- and carbapenemase-producing *E. coli* were screened from the imported poultry flocks intended for broiler meat, turkey meat and chicken egg production chains. The sampling is instructed by the Animal Health ETT ry and includes the majority of imported parent and grandparent flocks. Also, the import of eggs intended for broiler production are screened regularly. The liners of ten transport boxes were collected from each imported flock if possible and sent to the laboratory as soon as possible. If the import day was late Thursday, Friday or Saturday, the liners were moisturised with saline broth and kept at 4°C during the weekend.

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

Randomly selected samples of packed fresh and chilled (not frozen) meat from broilers (n=296) were collected at retail between February and December in 2020. However, due to COVID-19 pandemic, sampling was suspended from the beginning of April until the end of May 2020. Sampling was originally planned to be evenly distributed throughout the study period, but the adjustments were made to the sampling plan in the autumn 2020 so that the target number of 300 samples would be achieved. Sampling was allocated according to meat batches. Samples were collected from retail shops in five different NUTS-3 areas, covering approximately 55% of the Finnish population. Because of the nature of the Finnish market (small size, only a few distributors), same batches of the product can be found throughout the country. Samples were collected from Monday to Thursday except for the biggest NUTS-3 area, where samples were also collected on Fridays. The meat samples were sliced or diced and wrapped in vacuum or in a controlled atmosphere. All samples were of domestic origin. The samples were transported refrigerated to the laboratory within one day and the temperature of the meat was measured at the laboratory at arrival. One isolate from each epidemiological unit (if available) was selected for susceptibility testing.

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 Finnish Food Authority, Veterinary Bacteriology and Pathology Unit.

C. jejuni from broilers were isolated at slaughterhouse laboratories and confirmed at Finnish Food Authority, Microbiology Unit, according to ISO 10272-1:2017. *C. jejuni* from cattle were isolated according to ISO 10272-1:2017 with modifications. Briefly, 10 g of faeces were enriched in either 90 ml of Bolton and Preston broths or only Bolton broth and incubated 41.5 C for 24 ± 2 h. Subsequently, 10 µl was cultivated on mCCD and Preston agars, or only mCCD agar, and incubated at 41.5 for 44 ± 4 h.

Isolation and identification of *C. jejuni* from fur animals was performed by accredited conventional culture and biochemical/MALDI-TOF methods at Finnish Food Authority, 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 at Finnish Food 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 screening of ESBL/AmpC and carbapenemase producing *E. coli* from broilers (n=309) and cattle (n=295) was done from the same samples as the isolation of indicator *E. coli*. Meat samples from broilers (n=296) were screened as part of the EU-wide monitoring based on Commission Decision 2013/652/EU according to the EURL protocols. 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 imported poultry flocks was performed using the same methodology analysing the liners from each imported flock as two combination samples (liners from 5 transport boxes suspended in 3 litres 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 (5th ed) using Sensititre™ (TREK Diagnostic Systems Ltd, United Kingdom) microtiter plates except for *Brachyspira* spp. for which VetMIC™ (Department of Antibiotics, National Veterinary Institute, Uppsala, Sweden) or MICRONAUT-S Brachyspira MIC (MERLIN A Bruker Company, Germany) were used. 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 and* 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 Microbiology Unit and for *Brachyspira* spp. at Veterinary Bacteriology and Pathology Unit. The current (1.7.2021) 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 CLSI documents (CLSI VET08, 2018 or CLSI M100, 2019) were used to evaluate clinical resistance in animal pathogens. For *Brachyspira* spp., no standardised breakpoints exist, and laboratory-specific breakpoints are used to evaluate clinical resistance.

Table 28. *Cut-off values (mg/L) for resistance used in this report. Values represent EUCAST epidemiological cut-offs (ECOFFs) (1.7.2021). If EUCAST ECOFF was missing or different cut-off value was used it is stated in the footnote.*

Substance	*Salmonella enterica*	*Escherichia coli*	*Campylobacter jejuni*	*Staphylococcus aureus*
Ampicillin	>4	>8		
Azithromycin	>16	>16[1]		
Cefotaxime	>0.5	>0.25		
Cefoxitin				>4
Ceftazidime	>2	>0.5		
Chloramphenicol	>16	>16		
Ciprofloxacin	>0.06	>0.06	>0.5	
Colistin	[2]	>2		
Enrofloxacin		>0,125		
Erythromycin			>4	
Florfenicol		>16		
Gentamicin	>2	>2	>1	
Meropenem	>0.06[1]	>0.06		
Nalidixic acid	>8	>8	>16	
Streptomycin		>16	>4	
Sulfamethoxazole	>256[2]	>64[2]		
Tetracycline	>8	>8	>1	>1
Trimethoprim	>2	>2		
Trimethoprim/ sulfamethoxazole[3]		>1[4]		>0.25[1]

[1] tentative EUCAST ECOFF, [2] EUCAST ECOFF not available, [3] concentration of trimethoprim given, concentration ratio with sulfamethoxazole 1:20, [4] differs from ECOFF

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) was 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 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 antibiotic 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.

Appendix 4. Salmonella serovars isolated from food-producing animals in 2020

Table 29. *Salmonella enterica serovars isolated from the main food-producing animal species in Finland in 2020.*

Serotype	Nr of isolates	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	13	10	1	2	
monophasic *S.* Typhimurium	2	1	1		
S. Enteritidis	6	3	2	1	
S. Derby	3		3		
S. Infantis	3	2		1	
S. ssp. IIIb (= diarizonae)	2	1		1	
S. Konstanz	2	2			
S. Montevideo	2		2		
S. Bispebjerg	1	1			
S. Kedougou	1	1			
S. Mbandaka	1		1		
S. Nuorikkala	1	1			
Sum	**37**	**22**	**10**	**5**	**0**

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