FINNISH FOOD AUTHORITY
Ruokavirasto • Livsmedelsverket

Publications
4/2023

FINRES-Vet 2022

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

Finnish Food Authority publications 4/2023

FINRES-Vet 2022

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

RUOKAVIRASTO
Livsmedelsverket • Finnish Food Authority

fimea
Lääkealan turvallisuus- ja kehittämiskeskus
Säkerhets- och utvecklingscentret för läkemedelsområdet
Finnish Medicines Agency

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Co-funded by the European Union

Authors and institutions participating in making the FINRES-Vet report

Finnish Food Authority

Suvi Nykäsenoja, Satu Olkkola, Marie Verkola, Mia Biström, Thomas Grönthal, Tiina Autio, Henriette Helin-Soilevaara, Mirja Raunio-Saarnisto

Finnish Medicines Agency Fimea

Katariina Kivilahti-Mäntylä, Tita-Maria Muhonen

Faculty of Veterinary Medicine, University of Helsinki

Elina Aimo-Koivisto

Acknowledgements

The coordinators of the FINRES-Vet programme wish to thank the meat inspection personnel of the Finnish Food Authority and the slaughterhouses for collecting the samples from animals at slaughter. Also, the personnel of the Finnish Food Authority who has participated in the meat sampling are acknowledged.

Any use of data from FINRES-Vet 2022 should include a specific reference to this report. Suggested citation: FINRES-Vet 2022, Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents, Finnish Food Authority, Helsinki, Finland, ISSN 2669-8307, ISBN 978-952-358-053-4 (pdf).

Antimicrobial resistance monitoring in zoonotic and indicator bacteria isolated from food-producing animals and food according to the Commission Implementing Decision (EU) 2020/1729 is co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

The image on the cover page: Rodeo Oy

This report is available at www.ruokavirasto.fi or www.foodauthority.fi.

Description

Publisher	Finnish Food Authority
Authors	Finnish Food Authority, Finnish Medicines Agency Fimea, University of Helsinki
Title of publication	FINRES-Vet 2022. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Series and publication number	Finnish Food Authority publications 4/2023
Publications date	November 2023
ISBN PDF	978-952-358-053-4
ISSN PDF	2669-8307
Pages	62
Language	English
Keywords	Antibiotic resistance, consumption of antibiotics
Publisher	Finnish Food Authority
Layout	Finnish Food Authority
Distributed by	Online version: foodauthority.fi

Abstract

Sales of veterinary antibiotics for food-producing animals decreased by 13 % in 2022. The result was the lowest since the beginning of monitoring. The majority of overall sales consisted of products for individual treatment whereas the proportion of products for group treatment was roughly over a quarter. Sales decreased for almost all antibiotic classes. The largest decrease in sales was noted for orally administered oxytetracyclines and sulfa-trimethoprim-combination. Injectable penicillin continued to be the most sold veterinary antibiotic. Sales of critically important antibiotics (HPCIA, WHO) for the treatment of animals decreased further and remained very low.

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 from food-producing animals and campylobacter from broilers, resistance levels were low. Resistance situation among indicator *E. coli* from slaughtered broilers has remained good. The prevalence of ESBL/AmpC-producing bacteria in slaughtered broilers and broiler meat was low in 2022. No ESBL/AmpC-producing bacteria were detected in turkey meat samples at retail.

The resistance situation among pathogenic bacteria isolated from food-producing animals remained similar to 2021. Resistance was overall low in bovine and porcine respiratory pathogens as well as in pathogens isolated from broilers. Resistance was still detected most in enterotoxigenic *E. coli* from pigs. Among bacteria isolated from companion animals, the changes in resistance situation were mostly small. The proportion of canine *E. coli* strains resistant to third-generation cephalosporins was the lowest since the start of the monitoring.

Kuvailulehti

Julkaisija	Ruokavirasto
Tekijät	Ruokavirasto, Lääkealan turvallisuus ja kehittämiskeskus Fimea, Helsingin yliopisto
Julkaisun nimi	FINRES-Vet 2022. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Julkaisusarjan nimi ja numero	Ruokaviraston julkaisuja 4/2023
Julkaisuaika	Marraskuu 2023
ISBN PDF	978-952-358-053-4
ISSN PDF	2669-8307
Sivuja	62
Kieli	Englanti
Asiasanat	Antibioottiresistenssi, antibioottien kulutus
Kustantaja	Ruokavirasto
Taitto	Ruokavirasto
Julkaisun jakaja	Sähköinen versio: ruokavirasto.fi

Tiivistelmä

Tuotantoeläinten antibioottien myynti väheni 13 % vuonna 2022. Tulos oli matalin seurannan aloittamisen jälkeen. Valtaosa antibiooteista annettiin eläinyksilöille, ryhmälääkityksinä annettavien antiboottien osuus oli reilu neljännes. Myynti väheni lähes kaikissa antibioottiryhmissä. Eniten väheni suun kautta annettavien oksitetrasykliinin ja sulfa-trimetopriimi-yhdistelmän myynti. Myös seuraeläinten antibioottitabletteja myytiin aikaisempaa vähemmän. Injektiopenisilliini oli edelleen eniten käytetty eläinten antibiootti. Ihmisten reserviantibioottien myynti (HPCIA, WHO) pieneni edelleen ja oli erittäin vähäistä.

Eläimistä ja elintarvikkeista eristettyjen bakteerien antibioottiresistenssitilanne Suomessa on pysynyt suhteellisen hyvänä. Joillakin bakteerilajeilla 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 vuonna 2022 vain vähän. Teurasbroilereista eristettyjen *E. coli* -indikaattoribakteerien resistenssitilanne on pysynyt hyvänä. ESBL/AmpC-bakteereiden esiintyminen suomalaisissa teurasbroilereissa ja tuoreessa broilerinlihassa oli vähäistä vuonna 2022. Vähittäismyynnissä olevasta kalkkunanlihasta ei todettu ESBL/AmpC-bakteereita lainkaan.

Tuotantoeläinten patogeenien resistenssitilanne pysyi samankaltaisena vuoteen 2021 verrattuna. Resistenssiä todetaan yleisesti ottaen vähän nautojen ja sikojen hengitystietulehduksia aiheuttavissa bakteereissa sekä broilereilta eristetyissä patogeeneissa. Eniten resistenssiä todettiin edelleen sikojen enterotoksisilla *E. coli* -kannoilla. Seura- ja harraste-eläimistä eristettyjen bakteerien resistenssitilanteen muutokset olivat pääasiassa pieniä. Kolmannen polven kefalosporiineille vastustuskykyisten koirien *E. coli* -kantojen osuus oli pienin koko seurantajakson aikana.

Beskrivning

Utgivare	Livsmedelsverket
Författare	Livsmedelsverket, Säkerhets- och utvecklingscentret för läkemedelsområdet Fimea, Helsinki Universitet
Publikationens titel	FINRES-Vet 2022. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Publikationsseriens namn och nummer	Livsmedelsverkets publikationer 4/2023
Utgivningsdatum	November 2023
ISBN PDF	978-952-358-053-4
ISSN PDF	2669-8307
Sidantal	62
Språk	Engelska
Nyckelord	Antibiotikaresistens, användningen av antibiotika
Förläggare	Livsmedelsverket
Layout	Livsmedelsverket
Distribution	Elektronisk version: livsmedelsverket.fi

Referat

Försäljningen av antibiotika för produktionsdjur minskade med 13 % år 2022. Resultatet var lägst sedan påbörjandet av uppföljningen. Största delen av antibiotikan gavs till djurindivider och drygt en fjärdedel var gruppläkemedel. Försäljningen minskade i nästan alla antibiotikagrupper. Speciellt försäljningen av oxytetracykliner och sulfa-trimetoprim-kombination som administreras oralt minskade. Också försäljningen av antibiotikatabletter för sällskapsdjur minskade. Den mest använda antibiotikan var fortfarande penicillin i injektionsform. Försäljningen av de kritiskt viktiga antimikrobiella ämnena (HPCIA, WHO) för behandling av djur minskade ytterligare och var 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.

Salmonellabakterier isolerad från finländska livsmedelsproducerande djur och campylobakterier isolerad från slaktkycklingar visade liten resistens. Resistenssituationen för *E. coli* -indikatorbakterier isolerade från slaktkycklingar har varit fortsatt god. Förekomsten av ESBL/AmpC-bakterier i finländska slaktkycklingar och broilerkött var liten år 2022. Inga ESBL/AmpC-bakterier hittades bland kalkonkött i detaljhandeln.

Resistenssituationen för patogener i produktionsdjur förblev liknande jämfört med 2021. I allmänhet var resistensen låg hos bakterier som orsakar luftvägsinfektioner hos nötkreatur och svin, liksom hos patogener isolerade från slaktkycklingar. Mest resistens hittades fortvarande i enterotoxiska *E. coli* -stammar från svin. Förändringar i resistenssituationen för patogener isolerade från sällskaps- och hobbydjur var huvudsakligen små. Andelen *E. coli* -stammar hos hundar som var resistenta mot tredje generationens cefalosporiner var den lägsta under hela uppföljningsperioden.

CONTENTS

Introduction

FINRES-Vet 2022 reports statistics on sales of veterinary antibiotics and antibiotic resistance in bacteria isolated from animals and food. This report covers the latest results from 2022 but includes data also from previous years to enable a follow-up of trends.

The 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 the 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 2022, 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. An updated resistance monitoring in zoonotic and indicator bacteria in the European Union started in 2021 (Commission Implementing Decision (EU) 2020/1729) and it affected also in the mandatory targets, e.g. including meat imported from third countries.

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 certain population reflects the selection pressure caused by antibiotic use. 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.

The 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 aforementioned sources.

During the FINRES-Vet monitoring period which started in 2002, 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 2022 being the lowest since reporting began. Penicillin is the most used antibiotic and the majority of antibiotics are given to individual animals. However, 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 also at herd level and indicates the importance of preventive measures and the need to keep the prudent use guidelines updated.

1 Sales of antibiotics for use in animals

1.1 Changes in animal population

The overall number of food-producing animals from 2013 to 2022 showed a slight decrease. The number of cattle and pigs continued to decrease slowly, while a slow annual 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 2013, the PCU has decreased by 6% from 516 to 485 (thousand tons).

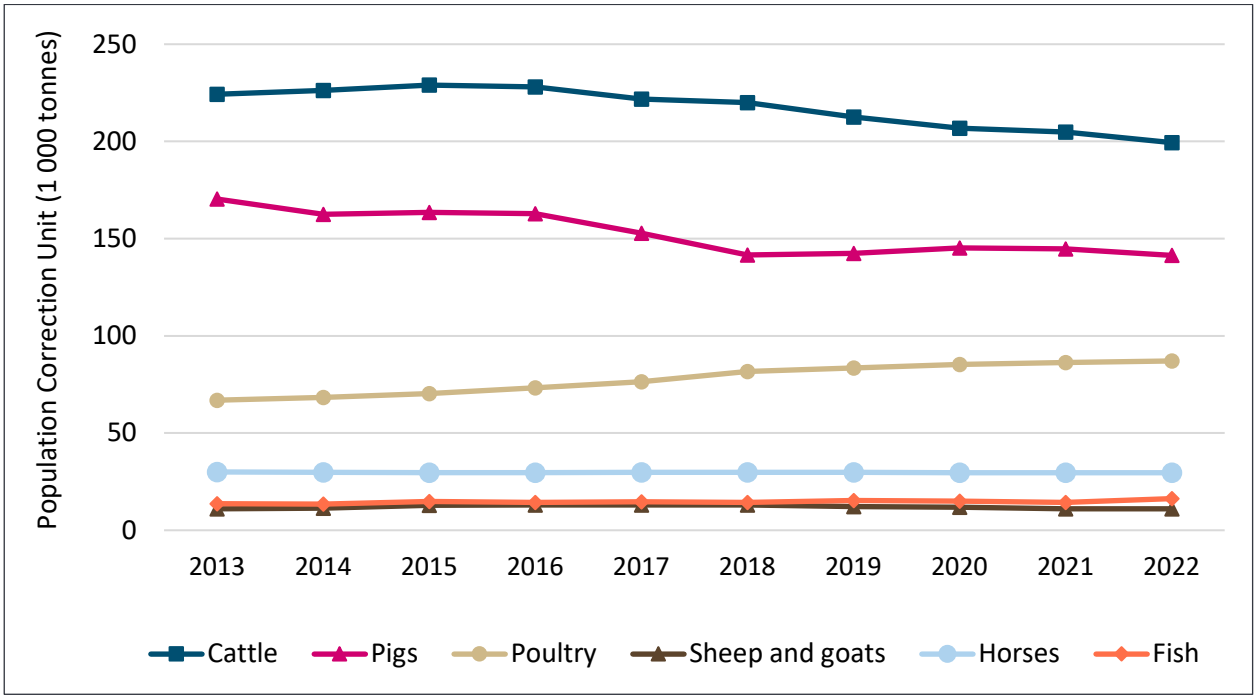

Figure 1. *Changes in food-producing animal population in Finland in 2013–2022, PCU (1 000 tonnes). Detailed data on the PCU of food-producing animals in a tabulated form is presented in Appendix 1.*

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. It has been estimated that the number of companion animals has increased during the COVID-19 pandemic. According to a survey commissioned by the Finnish Kennel Club, there were approximately 800 000 dogs in Finland in 2023. The number of fur animals have changed quite a lot during the last decade (FIFUR Statistics, 2023). The number of cubs born were at highest about 4.7 million animals in 2015 equaling to estimated 30 tonnes of live animals. Thereafter, a strong downward trend is seen. Decrease from 2021 to 2022 was 36% resulting in 1.3 million cubs born in 2022.

1.2 Sales of antibiotics for treatment of animals

1.2.1 Background

Finnish Medicines Agency Fimea monitors the sales of veterinary antibiotics based on statistics obtained from pharmaceutical wholesalers. Sales data are available since 1995. This report includes data for 2013–2022. For a review of data for 1995–2012, see the FINRES-Vet reports covering the corresponding years.

In this report information on sales of orally administered products has been slightly revised compared to previous FINRES-Vet reports. Sales of tablets, which are almost exclusively used for companion animals, have been detached from sales of other orally administered products and are only presented separately (Figure 6 and Table 24B in Appendix 2). 'Orally administered antibiotics' in this report thus represent sales of products intended for treatment of food-producing animals and fur animals, and sales of tablets represent sales to companion animals. That said, some oral powder and oral solution products, solely used in companion animals, are still included in the sales of orally administered products, but their proportion is very small; less than 0.5% (of orally administered antibiotics) in 2013–2022.

In 2010, the data collection method was harmonised with the protocol of the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. The data also covers sales figures for veterinary antibiotics that are used according to a special licence (exemption from a requirement for a marketing authorisation in Finland i.e., veterinary antibiotic products obtained from other Member States and permitted to be released for consumption for use in specified animal species). In 2022, their proportion was approximately 4% of the overall sales.

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, sales of tubes per cow is also reported. It should be noted that the 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 livestock population 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 and 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.

1.2.2 Overall sales (kg active ingredient)

Overall sales of veterinary antibiotics decreased by 15% in 2022 (Figure 2, Table 22 in Appendix 2). The 2022 sales, 7 979 kg, is the lowest ever reported in Finland. Sales either decreased or remained stable for all antibiotic classes and forms.

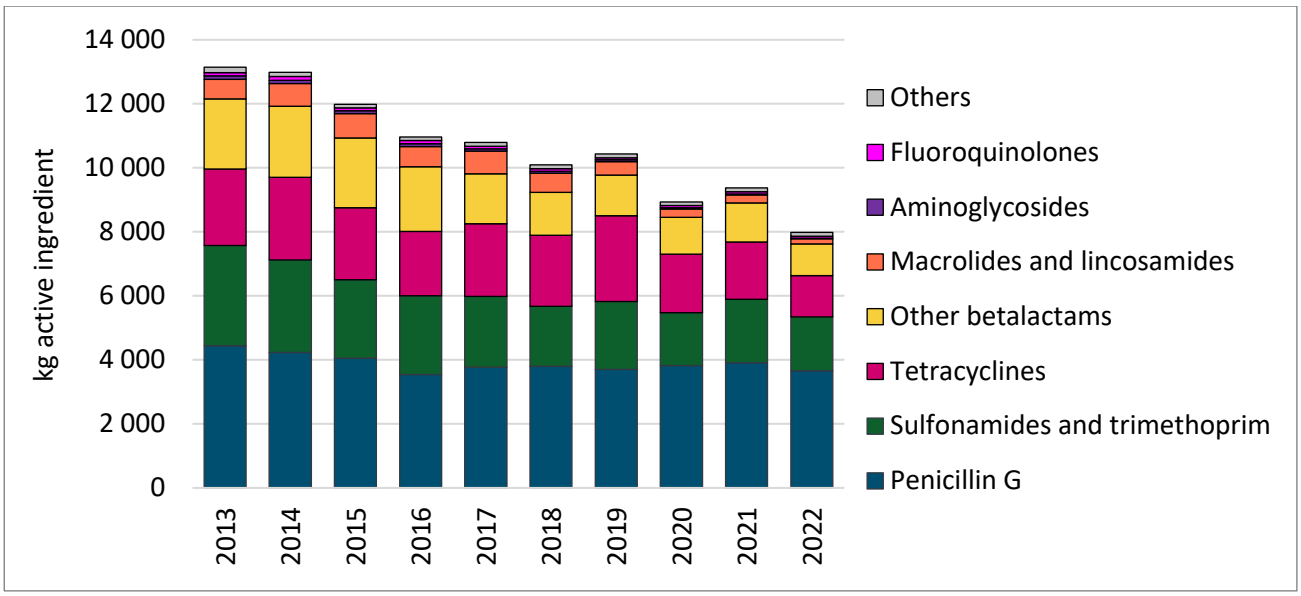

***Figure 2**. Overall sales (kg active ingredient) by class in 2013–2022 (tablets included). Other betalactams = aminopenicillins, cephalosporins and cloxacillin. Others = pleuromutilins, amphenicol and imidazole derivatives. For detailed data in tabulated form, see Appendix 2.*

The most-sold antibiotics were benzylpenicillin (46%), sulfonamide-trimethoprim combinations (21%) and tetracyclines (16%) (Figure 2). Of the antibiotic classes considered as critically important in human medicine (HPCIA) by both EMA and WHO (EMA, 2019 and WHO, 2019), only two are authorised for use in animals in Finland, namely fluoroquinolones, and 3rd generation cephalosporins. The proportion of sales for these remained low to extremely low (fluoroquinolones 0.8% and 3rd generation cephalosporins 0.002%). WHO considers also macrolides as HPCIA, their sales for use in animals in Finland was low (1% of the overall sales in 2022, Table 22 in Appendix 2).

1.2.3 Proportion of individual treatment vs. group treatment (tablets excluded)

Almost three quarters (74%) of antibiotics sold for treatment of food-producing and fur animals (in kg active ingredient) in 2022 were pharmaceutical forms intended for the treatment of individual animals (injectables, oral pastes and intramammary products). The proportion of products applicable for group treatment (premixes, oral powders, and oral solutions) was slightly over a quarter of the overall sales (Figure 3).

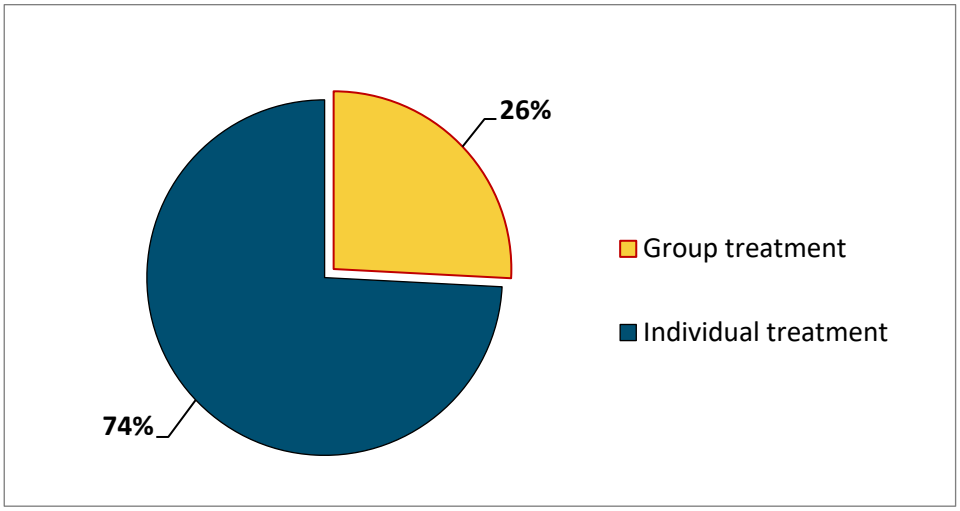

***Figure 3**. Sales of veterinary antibiotics for treatment of food-producing animals and fur animals by treatment type (group vs. individual) in 2022 (tablets excluded). Group treatment: premixes, oral solutions, and oral powders. Individual treatment: injectables, intramammaries and oral paste.*

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

Injectables

Over half of the antibiotics sold (63%) were products administered as injections to animals (see Appendix 2). Narrow spectrum penicillin continued to be by far the most sold injectable (77%) followed by tetracyclines (12%) and aminopenicillins (5%) (Figure 4A). Overall sales of injectables decreased by 7% from 2021 to 2022 and involved almost all antibiotic classes. Sales dropped especially for certain low selling injectables (less than 20 kg/year), namely amphenicols (-34%), macrolides (-25%) and aminoglycosides (-22%), but also for the three most selling injectable classes i.e., penicillin G (-6%), tetracyclines (-10%) and aminopenicillins (-21%).

Orally administered products (tablets excluded)

Sales of orally administered veterinary antibiotics, excluding veterinary antibiotic tablets, are presented in Figure 4B. A clear downward trend since 2014 is observed, but annual variation has been significant especially in recent years. From 2021 to 2022, sales of orally administered products dropped by 24% while the year before an increase of 10% was seen. The decrease in 2022 concerns almost all antibiotic classes administered orally but particularly tetracyclines (-37%) and macrolides (-45%), both classes resulting in lowest sales since 2010. A drop in sales of sulfonamide-trimethoprim combination was also marked (-16%). Annual variation is common also for penicillin and amoxicillin that are available mainly on special licence. Zero sales were reported for orally administered pleuromutilins (Table 24A in Appendix 2).

Decreased sales are not explained by the changes in the population of food-producing species (Figure 1, Tables 17 and 18 in Appendix 1). While the overall population of food-producing animals has decreased since 2016 the magnitude of change is clearly smaller than the drop in overall sales as detected also in population corrected sales (Section 1.2.5). Species-specific data is not available, but sales can also be monitored by product and veterinarian (Wholesaler statistics; Finnish Food Authority data, not publicly

available). Considering these, the increase in sales of oxytetracycline in 2021 and a subsequent decrease in 2022 can partially be linked to veterinarians treating farmed fish and explained by annual fluctuations in susceptible pathogens (Finnish Food Authority 2023a; Animal diseases in Finland).

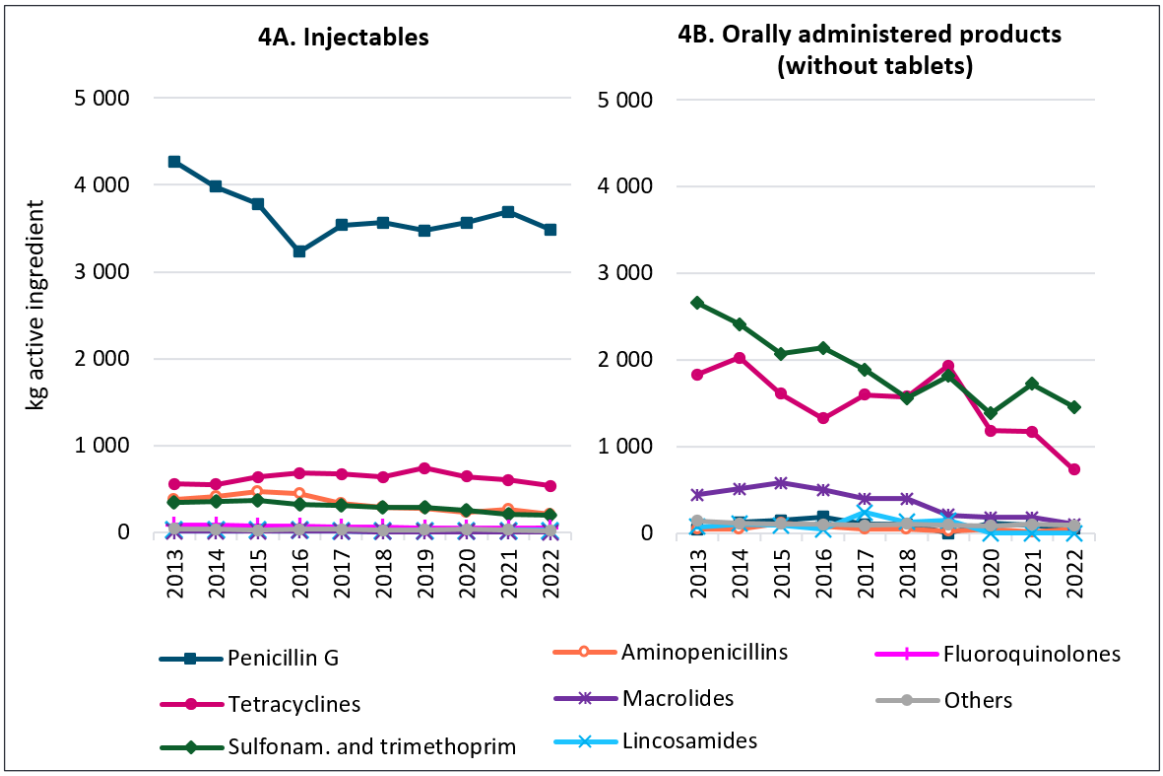

Figure 4A and 4B. *Trends in sales of injectable (4A) and sales of orally administered veterinary antibiotics without tablets (4B) in 2013–2022. Other injectables = amphenicols, aminoglycosides and cephalosporins. Other oral products = amphenicols, 1st gen. cephalosporins and pleuromutilins. Detailed data in tabulated form is presented in appendix 2.*

To note is that a decreasing trend in sales of orally administered macrolides has been seen already since 2016 (-83%). Considering information on bacterial species isolated from porcine clinical samples (Fact box 1), the single most significant infection in pigs treated with macrolides is proliferative enteritis caused by *Lawsonia intracellularis*. Since 2014, new vaccines have been available for immunisation of pigs against *L. intracellularis* (Finnish Medicines Agency, Medicine search). Assuming that pigs are vaccinated only once, the estimated proportion of pigs vaccinated against *L. intracellularis* in Finland has gradually increased to almost 40% in 2022 (Fact box 2). The increase in sales of these vaccines is timely associated with decreasing sales of orally administered macrolides. That said, it is acknowledged that also management measures to prevent diarrhoea in growing pigs have improved over time and vaccinations may therefore be seen as one tool of several management measures.

Fact box 1. National prudent use guidance on macrolides in pigs and incidence of associated infections in Finland

Macrolides are the first choice for treatment of two infectious diseases in pigs, namely proliferative enteritis caused by *Lawsonia intracellularis* and arthritis caused by *Mycoplasma hyosynoviae*. In addition, they are mentioned as second choice and based on susceptibility testing for the treatment of gastrointestinal infections caused by *Brachyspira* spp.

According to Finnish Food Authority Open data, *L. intracellularis* is a common finding in pigs. The number of *L. intracellularis* positive farms increased through the 2010s but seems to have turned to a decrease after 2020, acknowledging that the number of sampled farms is very low. By contrast there is no information on the incidence of *M. hyosynovie* in Finland, nevertheless, it is assumed to be rare. Only sporadic cases of *Brachyspira hyodysenteriae* have been reported since 2015 (Open data). The policy for over two decades already has been to eradicate this disease (Evira 2016) which based on Open data has been a successful method.

Brachyspira pilosicoli on the contrary is more commonly reported. Antibiotic treatment options available for *B. pilosicoli* associated infections have decreased during recent years as certain antibiotic classes are no longer marketed in Finland. Use of macrolides, which is the second choice class, has not increased despite the fact that the first choice antibiotic tiamulin has not been available during 2021–2022. Therefore, it is assumed that the need for the use of antibiotics, including macrolides, for treatment of diarrhea caused by *Brachyspira* spp. has been low.

Fact box 2. Trends in sales of orally administered macrolides in pigs and in sales of *Lawsonia intracellularis* vaccines for pigs

Most veterinary antimicrobials are authorised for several species, but all orally administered macrolides in Finland are indicated for pigs only. Nevertheless, national prudent use guideline advises to use tylosin and/or macrolides also for the treatment of fur animals and poultry. According to Animal Health ETT data, tylosin or other macrolides have not been used in the treatment of broilers or turkeys since 2010 (Animal Health ETT, 2023). Statistics on medicated feed are available regarding the use of macrolides in fur animals (Finnish Food Authority, 2023b) and the corresponding amount was subtracted from the sales of all orally administered macrolides. Changes in the number of pigs between years were taken into consideration by applying the population correction unit to obtain macrolide sales in pigs in mg/PCU (EMA, 2011).

Lawsonia intracellularis vaccines for the immunisation of pigs were first introduced in Finland with special licence in 2014 and the first marketing authorisations were granted in 2017. The number of *L. intracellularis* vaccine doses available for treatment of pigs was obtained from sales statistics and the estimated proportion of fattening pigs vaccinated against *L. intracellularis* was calculated by dividing the number of doses sold by the number of pigs slaughtered (Natural Resources Institute Finland, 2023).

Figure 5 below presents trends in population corrected sales of orally administered macrolides in pigs and the estimated proportion of pigs vaccinated annually against *Lawsonia intracellularis* in Finland.

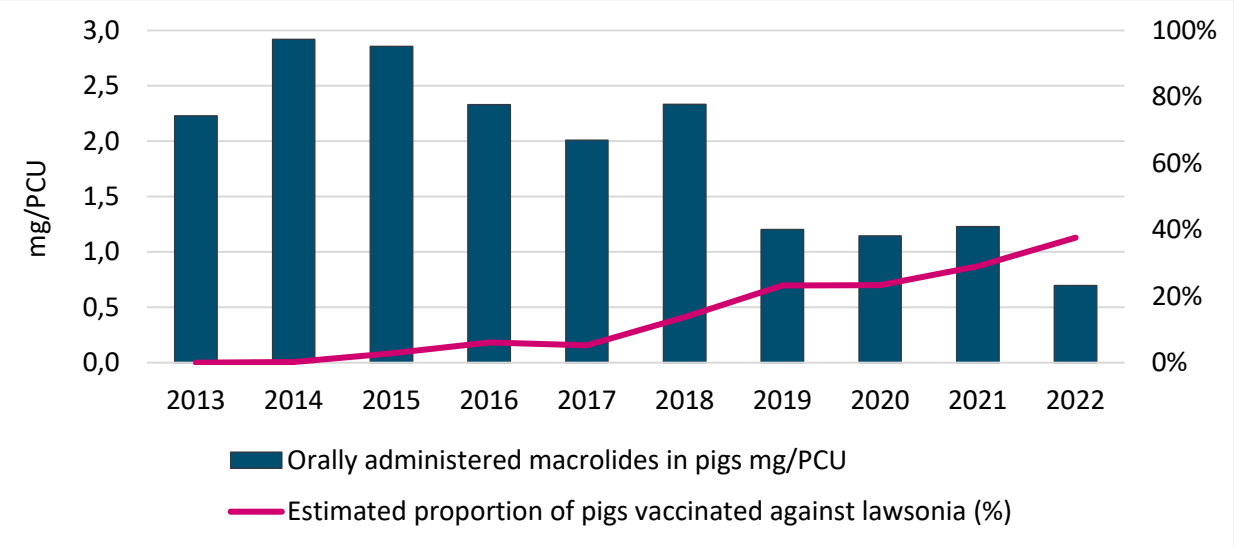

Figure 5. *Trends in sales of orally administered macrolides in pigs (mg/PCU) and estimated proportion of pigs vaccinated against Lawsonia intracellularis (%) in 2013–2022.*

Tablets

Veterinary antibiotic tablets are almost solely used for the treatment of companion animals. Their sales decreased by 22% from 2021 (Figure 6) and have more than halved since 2011. Decrease from 2021 was mainly due to decreased sales of aminopenicillins, which principally consists of aminopenicillin and clavulanic acid combination (>95% of sales of aminopenicillins). A decreasing trend in sales of 1st generation cephalosporins continued, their sales in 2022 being 23% less than in 2021 and 83% less than in 2013. Annual sales for other antibiotic classes available as veterinary tablets were low (less than 35 kg). Sulfonamide-trimethoprim combination is available through special licence arrangements. Veterinary tablets containing tetracyclines or imidazole derivative have been on the market for a few years (included in 'Others'). It should be noted that this report contains only sales of veterinary antibiotic products. The amount of human medicinal products prescribed for use in companion animals is not known as their sales are not captured with the current methodology. Such data collection would require an electronic prescribing or other data collection system, which is currently not available for veterinarians in Finland. Legislation, nevertheless, requires veterinarians to choose a veterinary medicinal product if such is available.

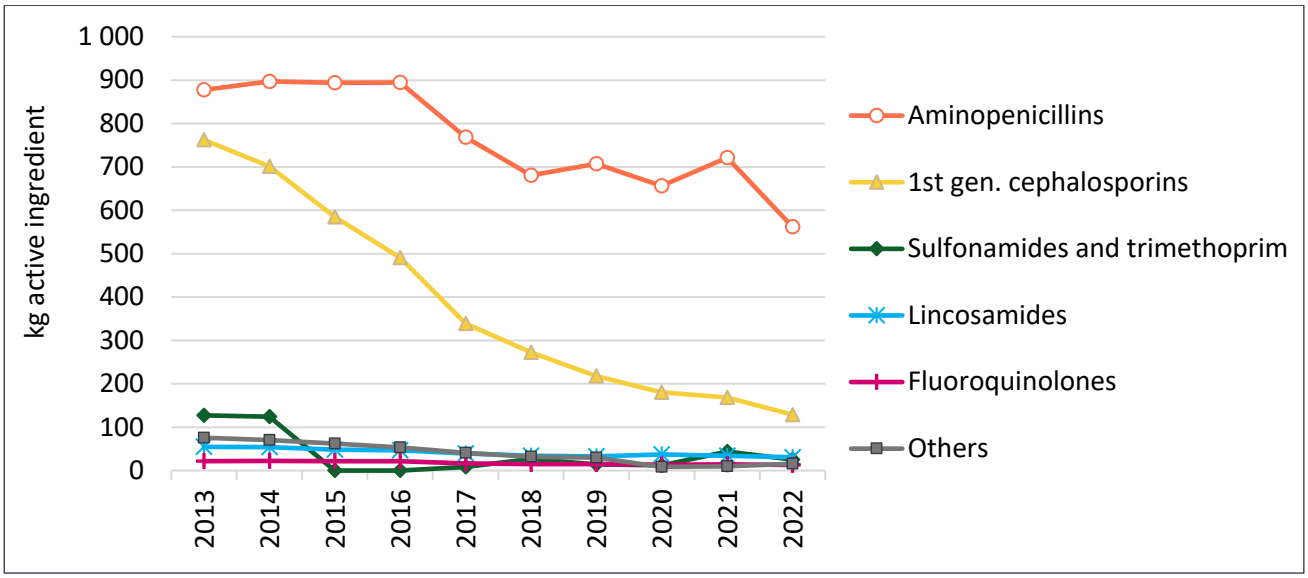

Figure 6. *Sales of antibiotic tablets to companion animals (kg active ingredient) by class. Others include tetracyclines, imidazole derivatives and aminoglycosides.*

Intramammaries

In 2022, a large-scale shortage concerning dry cow intramammary products caused a disturbance in availability. Special licence arrangements were used to compensate the situation but were not fully able to resolve the shortage. Sales of dry cow products per cow have been stable through the last decade but dropped within a year by 22% to an all-time low in 2022 (Figure 7). A decreasing trend in sales of intramammary products for the lactation period continued. In ten years, sales have decreased by 44% and were less than one tube per cow during the lactation period for a second year in a row. Over 80% of the intramammary tubes used during the lactation phase contained narrow spectrum penicillin and the proportion of cloxacillin was 18%. Correspondingly, the most-used antibiotic in intramammaries for the dry

period was penicillin (53%) followed by cloxacillin (25%) and aminoglycosides (22%) (Tables 25A and 25B in Appendix 2).

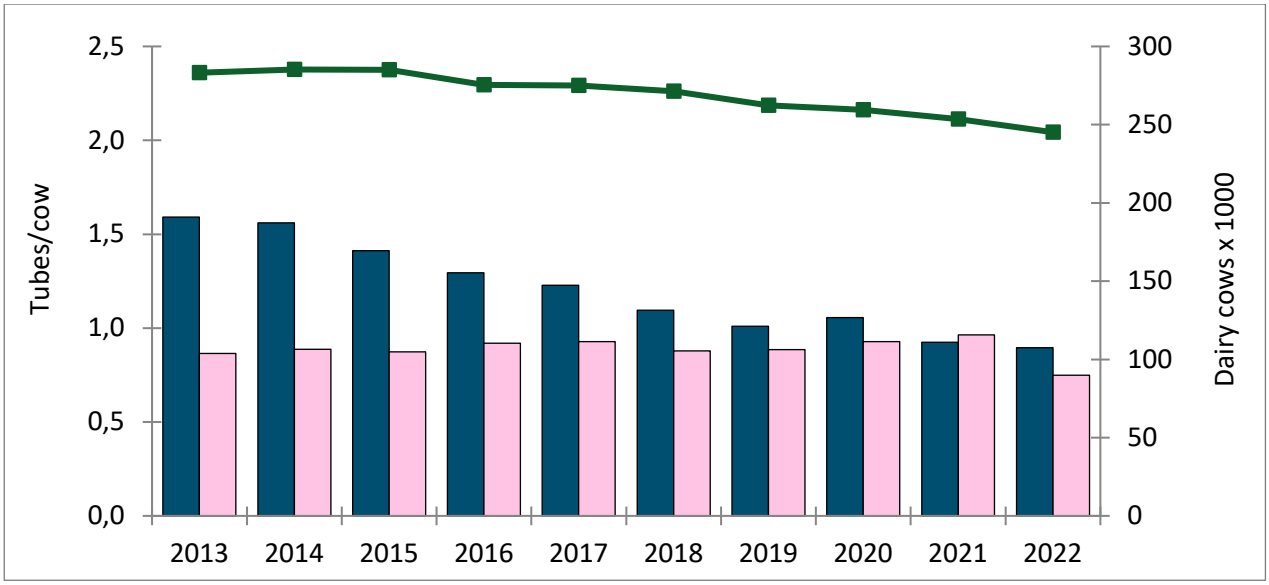

Figure 7. *Antibiotics for intramammary use per cow during lactation period (blue column) and during dry cow period (pink column) and the number of dairy cows (green curve).*

1.2.5 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 the occurrence of antibiotic resistance in both humans and food-producing animals (ECDC, EFSA and 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 exclusively used for the treatment of companion animals. Injectable antibiotic products are often authorised for both food-producing and companion animals, however, it has been estimated that the 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, 2022). For certain injectable antibiotic classes that in Finland are only allowed for use in companion animals and foals, e.g. 3rd generation cephalosporins, their inclusion in population corrected sales results in an overestimation of the use in food-producing animals.

All three EU-indicators reached their all-time low in 2022. Overall sales of veterinary antibiotics for food-producing animals decreased by 13% (-2.2 mg/PCU) and were 14.9 mg/PCU (Table 1). Sales of 3rd generation cephalosporins decreased by 15% and fluoroquinolones by 14%, resulting in 0.0003 mg/PCU and 0.10 mg/PCU, respectively.

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)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Overall sales[1]	21.7	21.7	20.0	18.1	18.8	18.1	19.0	16.2	17.1	14.9
Fluoroquinolones	0.16	0.18	0.14	0.15	0.12	0.13	0.10	0.11	0.11	0.10
3rd generation cephalosporins[2]	0.016	0.016	0.014	0.006	0.001	0.001	0.0005	0.0004	0.0004	0.0003

[1]Sales of two presentations corrected, effect < 1 % per year. [2] Since 2017, sales of 3rd generation cephalosporins only for treatment of foals and companion animals.

For decades, 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 programmes to achieve good animal health. If antibiotics, however, are needed, they should be used in accordance with the national prudent use guidelines (available since 1996, updated three times, most recently in 2016). In 2014, a requirement of susceptibility testing before using the highest priority critically important antibiotics was added to the national legislation. An overview of the strategic actions implemented since 1949 is available at the Finnish Food Authority website (Finnish Food Authority 2023c).

1.3 Sales of coccidiostats and antibiotic feed additives for use in animals

The Finnish Food Authority monitors the annual consumption of feed additives by collecting data from feed manufacturers. In 2022, only coccidiostats diclazuril, monensin sodium 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 (Table 2). Compared to 2013, the use of coccidiostats has increased approximately 70%.

Table 2. *The use of coccidiostats, antibiotic and other substances in feed in Finland 2013–2022 (kg active substance/year).*

Substance	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coccidiostats										
Decoquinate	0	0	0	0.1	0	0	0	0	0	0
Diclazuril	0	0	0	0	0.8	0.5	0.04	0	0	0.15
Lasalocid sodium	0	0	0	0	0	1 336	0	0	0	0
Madmuramycin ammonium	0	0	0	0	0	0	0	0	0	0
Monensin sodium	4 614	6 677	12 640	15 373	14 693	5 097	13 979	14 710	14 767	17 410
Narasin	9 626	9 022	5 478	5 026	4 918	13 152	6 535	6 084	6 428	6 191
Nicarbazin	0	0	0	0	0	0	0	0	117	0
Salinomycin	0	0	0	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0	0
Antibiotic substances										

Substance	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Avoparcin	0	0	0	0	0	0	0	0	0	0
Flavomycin	0	0	0	0	0	0	0	0	0	0
Carbadox	0	0	0	0	0	0	0	0	0	0
Olaquindox	0	0	0	0	0	0	0	0	0	0
Other substances										
Amprolium (and ethopabate)	0	0	0	0	0	0	0	0	0	0
Dimetridazole	0	0	0	0	0	0	0	0	0	0
Nifursol	0	0	0	0	0	0	0	0	0	0
Total	**14 240**	**15 699**	**18 117**	**20 399**	**19 613**	**18 585**	**20 514**	**20 795**	**21 312**	**23 601**

2 Antibiotic resistance in zoonotic bacteria

2.1 *Salmonella* from food-producing animals and domestic food

The prevalence of *Salmonella* in cattle, pigs, and poultry as well as in meat and eggs was monitored through the national *Salmonella* control programme (Ministry of Agriculture and Forestry, MAF, Decrees 1030/2013; 1037/2013; 134/2012). From May 2021, the *Salmonella* control programme was amended (MAF Decree on zoonoses 316/2021). The objective of the *Salmonella* control programme is to keep the annual incidence of *Salmonella* contamination among food-producing animals at a maximum of 1%, and in meat and eggs at a maximum of 1% or from May 2021, at a maximum of 0.5%. *Salmonella* has been 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.

In 2021, the susceptibility panel of the tested antibiotics changed: amikacin was added, and the concentration ranges changed for a few of the other antibiotics. 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 2022, 55 *Salmonella* isolates from food-producing animals were tested for susceptibility. Most of the isolates originated from cattle (n=37) and pigs (n=15). Two isolates originated from broilers and one from laying hens. The most common serotypes were *S*. Typhimurium (n=18) and *S.* Enteritidis (n=16). Other serotypes are shown in Appendix 4.

Resistance in *Salmonella* from food-producing animals was very low (Table 3). Monophasic *S*. Typhimurium was found in two cases from pigs and one of them showed a typical multidrug resistance pattern (ampicillin, sulfamethoxazole, trimethoprim). One *S*. Typhimurium resistant to ampicillin, sulfamethoxazole, tetracycline and trimethoprim was found from cattle. All other *Salmonella* isolates from food-producing animals in Finland were susceptible to the tested antibiotics.

Resistance situation of *Salmonella* isolated from Finnish food-producing animals has been very favourable for a long time and multidrug resistance has not been common. However, multidrug resistant *Salmonella* isolates have been detected in food-producing animals in Finland now in five consecutive years (Figure 8).

Table 3. *Distribution of MICs for Salmonella enterica from food-producing animals in 2022 (n=55).*

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	>512
Amikacin[1]	0	0.0–6.5									100								
Ampicillin	3.6	1.0–12.3							45.5	50.9					3.6				
Azithromycin	0	0.0–6.5								3.6	43.6	50.9	1.8						
Cefotaxime[1]	0	0.0–6.5					98.2	1.8											
Ceftazidime	0	0.0–6.5					58.2	40.0	1.8										
Chloramphenicol	0	0.0–6.5										92.7	7.3						
Ciprofloxacin	0	0.0–6.5	40.0	58.2	1.8														
Colistin[2]									85.5	12.7		1.8							
Gentamicin	0	0.0–6.5						76.4	23.6										
Meropenem[3]	0	0.0–6.5		70.9	29.1														
Nalidixic acid	0	0.0–6.5									96.4	3.6							
Sulfamethoxazole[4]	3.6	1.0–12.3										1.8	50.9	40.0	3.6				3.6
Tetracycline	3.6	1.0–12.3								96.4					3.6				
Tigecycline[5]							85.5	12.7	1.8										
Trimethoprim[1]	1.8	0.3–9.6					60.0	20.0	18.2					1.8					

Bold vertical lines indicate current (4.7.2023) EUCAST epidemiological cut-off (ECOFF) values for resistance for *Salmonella enterica*. 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]Tentative ECOFF. [2]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. [3]For meropenem, no EUCAST ECOFF is available, therefore, a cut-off value of >0.125 µg/mL is used (dashed vertical line) for resistance monitoring purposes. [4]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. [5]For tigecycline, no EUCAST ECOFF is available.

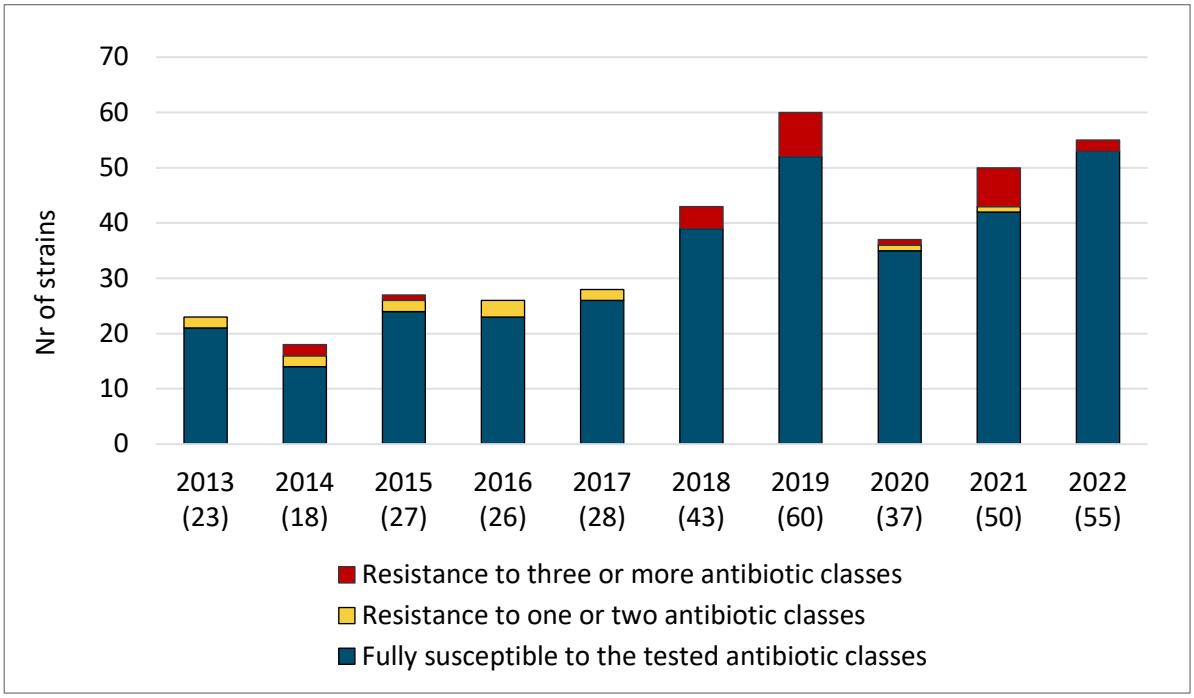

***Figure 8**. The number of sensitive and resistant Salmonella isolates from food-producing animals in Finland in 2013–2022. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides, beta-lactams, phenicols, quinolones, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

2.2 *Campylobacter* from food-producing animals

In 2022, *Campylobacter jejuni* from broilers were obtained from the national *Campylobacter* control programme. In 2021, the susceptibility panel of the tested antibiotics changed: chloramphenicol and ertapenem were added, and nalidixic acid and streptomycin were removed. To allow comparison to previous years, antibiotic susceptibility figures showing complete susceptibility and resistance to one, two or more antibiotic classes were analysed based on the susceptibility results of four antibiotics that remained the same before and after 2021 (ciprofloxacin, erythromycin, tetracycline and gentamicin). Also, in 2021 it became mandatory for the first time to report susceptibility results for *C. coli* from broilers in the EU (Commission implementing decision (EU) 2020/1729). In 2022, no *C. coli* isolates from broilers were detected in the national control programme.

2.2.1 *Campylobacter jejuni* from broilers

Within the national *Campylobacter* control programme of broilers in 2022, 70 *C. jejuni* isolates were tested for susceptibility. Of these, one (1.4%) was resistant to ciprofloxacin and another one (1.4%) had MIC-value one step above the new tentative ECOFF for ertapenem (Table 4). Resistance to the other studied antibiotics was not detected.

Table 4. *Distribution of MICs for Campylobacter jejuni from broilers in 2022 (n=70).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)													
			0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Chloramphenicol	0.0	0.0-5.2					98.6	1.4								
Ciprofloxacin	1.4	0.3-7.7	82.9	15.7						1.4						
Ertapenem[1]	1.4	0.3-7.7	98.6	1.4												
Erythromycin	0.0	0.0-5.2				100										
Gentamicin	0.0	0.0-5.2		10.0	85.7	4.3										
Tetracycline	0.0	0.0-5.2			100											

Bold vertical lines indicate current (4.7.2023) 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]Tentative ECOFF

Antibiotic resistance in *C. jejuni* from broilers has been monitored yearly since 2003. The proportions of resistant *C. jejuni* isolates have been quite stable until the year 2013 and the occurrence of resistant isolates has been mainly at a low level (Figure 9). However, the occurrence of quinolone resistance in *C. jejuni* has been more common in 2014, 2016, 2018 and 2019. In 2014 and 2016, quinolone resistance was commonly accompanied with tetracycline resistance whereas in 2018 and 2019, tetracycline resistance was not observed. Between 2020 and 2022, the proportions of quinolone and tetracycline resistant isolates have remained again at a low level. Resistance to erythromycin and gentamicin have remained low or non-existent throughout the monitoring period. The percentage of isolates susceptible to all the studied antibiotic classes has varied between 75% and 100%, with the lowest percentages in 2014 and 2018 paralleling the highest occurrences of quinolone resistance (Figure 10). Multidrug resistance has not been detected.

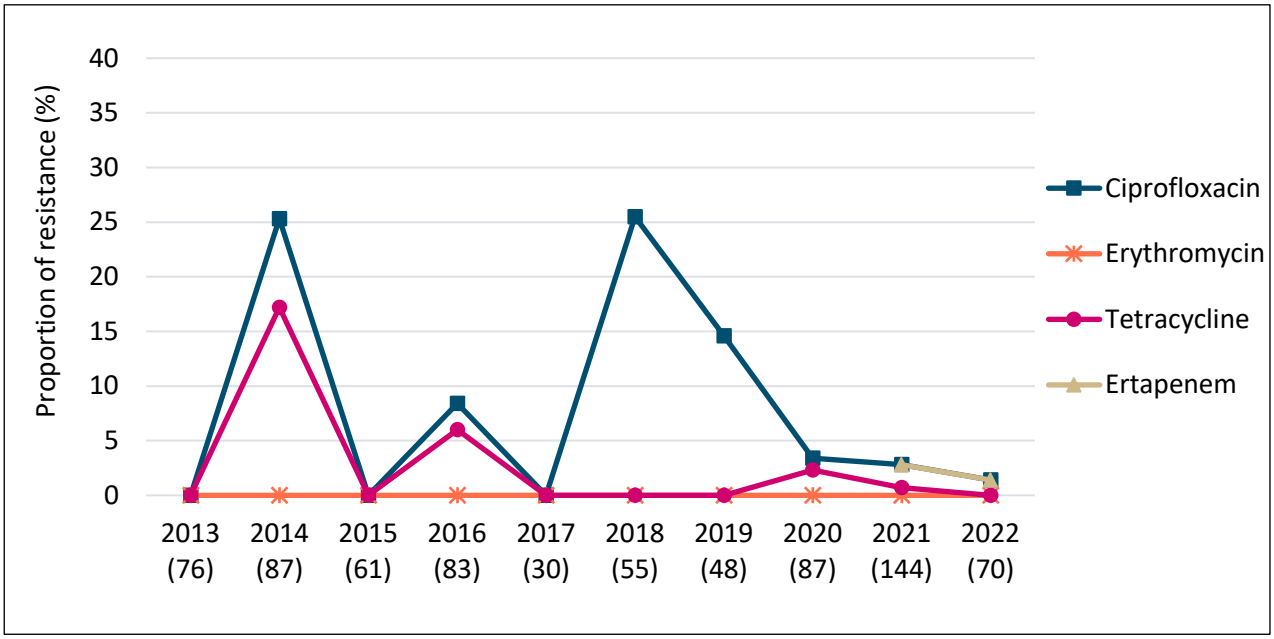

***Figure 9**. The proportions of resistant Campylobacter jejuni isolates from broilers at slaughter in Finland between the years 2013 and 2022. The number of isolates tested each year are in brackets.*

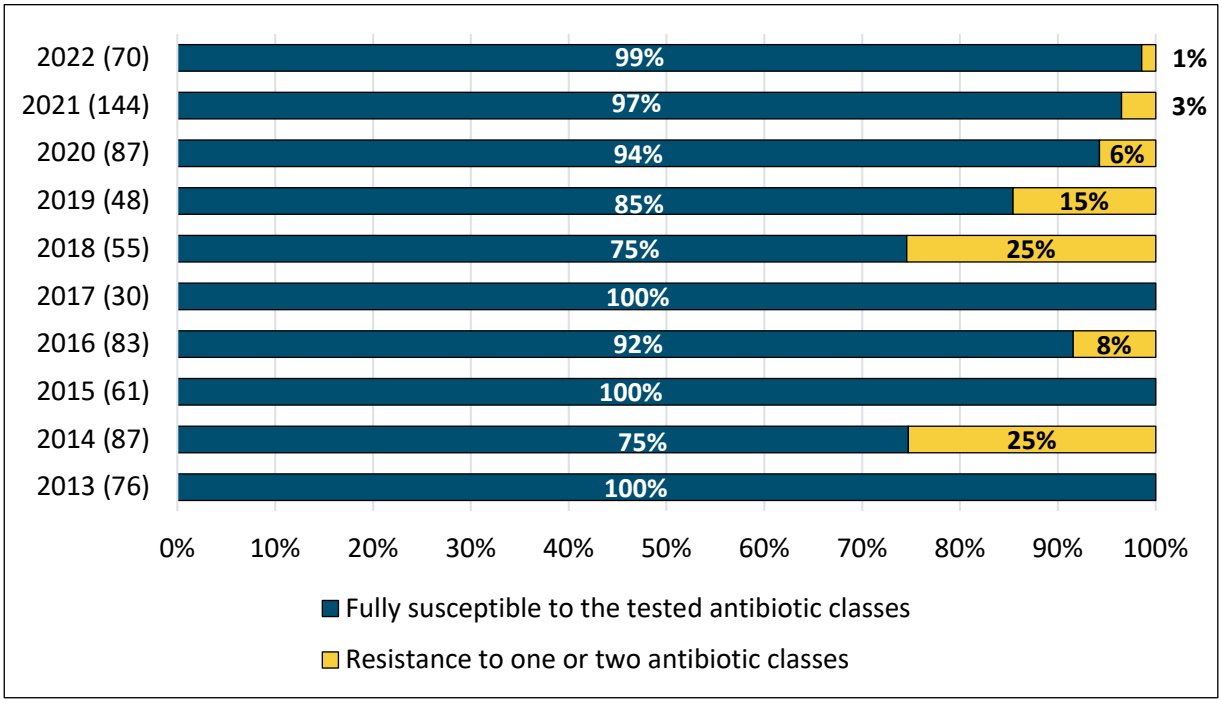

Figure 10. *Antibiotic susceptibility of Campylobacter jejuni isolated from broilers at slaughter in Finland between the years 2013 and 2022. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides (gentamicin), fluoroquinolones (ciprofloxacin), macrolides (erythromycin), and tetracyclines.*

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 (from 2021, (EU) 2020/1729). In Finland, these bacteria are screened from broilers, cattle, and pigs, as well as meat thereof, targeting broilers and meat from broilers and turkeys in 2022. In 2021, it became mandatory in EU to monitor also fresh meat originating from third countries according to (EU) 2020/1729. However, because fresh meat is rarely imported directly from third countries to Finland, the number of samples tested is very small or non-existent. 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* in broilers and meat from broilers and turkeys

In 2022, extended-spectrum beta-lactamase (including AmpC beta-lactamase) producing *E. coli* were screened with selective isolation method from broiler caecal samples (n=301) collected at slaughterhouses as well as from fresh broiler meat (n=300) and turkey meat (n=151) samples collected at retail. Consignments of fresh poultry meat were not imported to Finland in 2022, therefore, no samples from border control posts were analysed. All the meat samples collected from retail shops were of domestic origin. In 2022, the sampling method for broiler caecal samples was altered due to changes in EU legislation to comply with the new Commission implementing decision (EU) 2020/1729. Each sample was thus taken from a pooled sample of caecal content from ten birds instead of only one bird.

In 2022, the prevalence of ESBL- or AmpC-producing *E. coli* in broilers was 1.3% and 1.7% in broiler meat, while no ESBL- or AmpC-producing *E. coli* was detected in turkey meat. The detected prevalence in broiler meat was slightly higher than in 2020, but still significantly lower than in 2016 and 2018. However, due to the altered sampling method the prevalence in broilers cannot be compared with previous years. AmpC, the predominant phenotype in 2016 and 2018 was not detected in 2022 either (Table 5, Figure 11). Carbapenemase-producing *E. coli* was not detected in any of the samples. Molecular analysis of the isolates (n=9; five from broiler meat and four from broilers) revealed beta-lactamase genes *bla*TEM-1B (n=1, broiler meat isolate) and *bla*CTX-M-1 (n=9). ESBL/AmpC phenotypes corresponded with the molecular findings. In addition to beta-lactam resistance, one isolate from broilers was resistant to trimethoprim and a gene analysis confirmed resistance gene *dfrA5*.

Table 5. *Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing E. coli in food-producing animals and meat in 2016, 2018, 2020 and 2022.*

Year	Sampling stage	Nr of samples	Nr (%) of ESBL[1]	Nr (%) of AmpC[1]	Nr of CP-EC[2]	% ESBL/AmpC
Broilers						
2022	at slaughter	301[3]	4 (1.3%)	0 (0%)	0	1.3%
2020	at slaughter	309[4]	1 (0.3%)	0 (0%)	0	0.3%
2018	at slaughter	289[4]	5 (1.7%)	33 (11.4%)	0	13.1%
2016	at slaughter	306[4]	11 (3.6%)[5]	33 (11.1%)	0	14.4%
Broiler meat						
2022	at retail	300	5 (1.7%)	0 (0%)	0	1.7%
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%
Turkey meat						
2022	at retail	151	0 (0%)	0 (0%)	0	0%

[1] based on phenotypic characterization, see appendix 3.

[2] CP-EC, carbapenemase-producing *Escherichia coli*

[3] each sample pooled sample of caecal content from ten birds

[4] each sample from caecal content of one bird

[5] one isolate had also cefoxitin MIC of 16 i.e. presumptive ESBL+AmpC

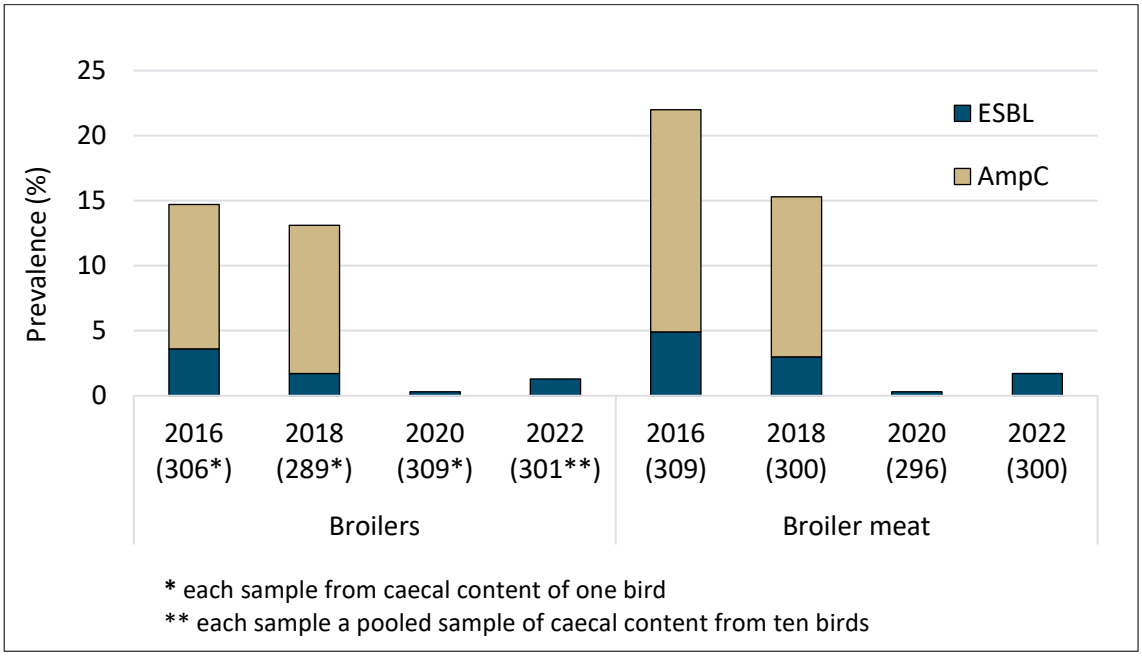

Figure 11. *Prevalence (%) of ESBL- and AmpC-producing E. coli in broilers and broiler meat in 2016, 2018, 2020 and 2022. The number of samples tested each year are in brackets.*

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

In 2022, liners of transport boxes of 29, four and four 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 6). This represents the majority of poultry flocks imported to Finland (see details in Appendix 3).

No ESBL/AmpC-producing *E. coli* were found in the imported poultry flocks in 2022. During the years 2015–2022, the proportion of positive flocks has fluctuated from 0 to 39% for the imported broiler production chain, and from 0 to 75% for the chicken egg production chain. Between 2018 and 2022, ESBL/AmpC-producing *E. coli* were found only from one imported poultry flock and thus the situation is very favourable. Carbapenemase-producing *E. coli* have not been detected.

Table 6. *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 2015–2022.*

Imported poultry flocks	2015	2016	2017	2018	2019	2020	2021	2022
For broiler meat production								
Nr of sampled flocks	54	62	37	42	38	34	35	20
Nr of ESBL positive flocks	1	0	0	0	0	0	0	0
Nr of AmpC positive flocks	9	24	8	0	0	0	0	0
Nr (%) of ESBL/AmpC positive flocks	10 (19%)	24 (39%)	8 (22%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
For turkey production								
Nr of sampled flocks	6	5	4	5	5	4	6	4
Nr of ESBL positive flocks	0	0	0	0	0	0	0	0
Nr of AmpC positive flocks	0	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%)	0 (0%)
For egg production								
Nr of sampled flocks	4	3	4	5	3	5	3	4
Nr of ESBL positive flocks	1	0	0	0	0	0	0	0
Nr of AmpC positive flocks	2	0	3	0	0	1	0	0
Nr (%) of ESBL/AmpC positive flocks	3 (75%)	0 (0%)	3 (75%)	0 (0%)	0 (0%)	0 (20%)	0 (0%)	0 (0%)

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. In 2022, the reported pathogens from pigs are *E. coli* and *Brachyspira pilosicoli* from porcine enteritis, and *Actinobacillus pleuropneumoniae* from respiratory and joint 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 the Finnish Food Authority. All isolates were confirmed by PCR to be enterotoxigenic. Altogether, 97 *E. coli* isolates from 46 different farms were included. The number of isolates and farms sending samples in 2022 was higher than in previous years due to a project that allowed susceptibility testing without costs to the farmer. However, the results are still not representative of the whole Finnish pig enteritis *E. coli* population but are likely to be closer to the whole population than previously. Furthermore, at least part of the isolates are 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 7. As before, resistance was commonly detected against ampicillin, fluoroquinolones, tetracycline, streptomycin, as well as sulfamethoxazole, trimethoprim, and their combination. The percentages of resistance, however, are overall slightly lower than in 2021 and 2020. Still, there is no decreasing trend between 2016 and 2022, and the resistance situation on pig enteritis *E. coli* remains worrying.

In 2022, resistance to chloramphenicol was low and no resistance to florfenicol was detected. Also, no resistance against gentamicin has been detected between 2016 and 2021. Resistance against 3rd generation cephalosporins (according to the epidemiological cut-off values) was detected in eleven isolates from ten farms, from which all were phenotypically AmpC. No ESBL-producers were found. In 2022, one isolate was resistant to colistin and a chromosomal point mutation causing resistance was found.

An upward trend in resistance levels against most antibiotics that was seen between 2016 and 2021 (Figure 12) was disrupted in 2022. This is probably due to a higher number of tested isolates in 2022, and therefore more representative sample size than in previous years. The proportion of multidrug resistance varies annually (Figure 13) and in 2022 it was roughly the same as before.

In summary, resistance was commonly detected against 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*. Thus,

taking diagnostic samples to determine the farm-specific resistance profiles of enterotoxigenic *E. coli* is very important. To avoid further selection of antibiotic resistance, the aim should be to minimize the need for antibiotic treatments, and only efficient drugs should be used in the treatment of *E. coli* diarrhea in pigs.

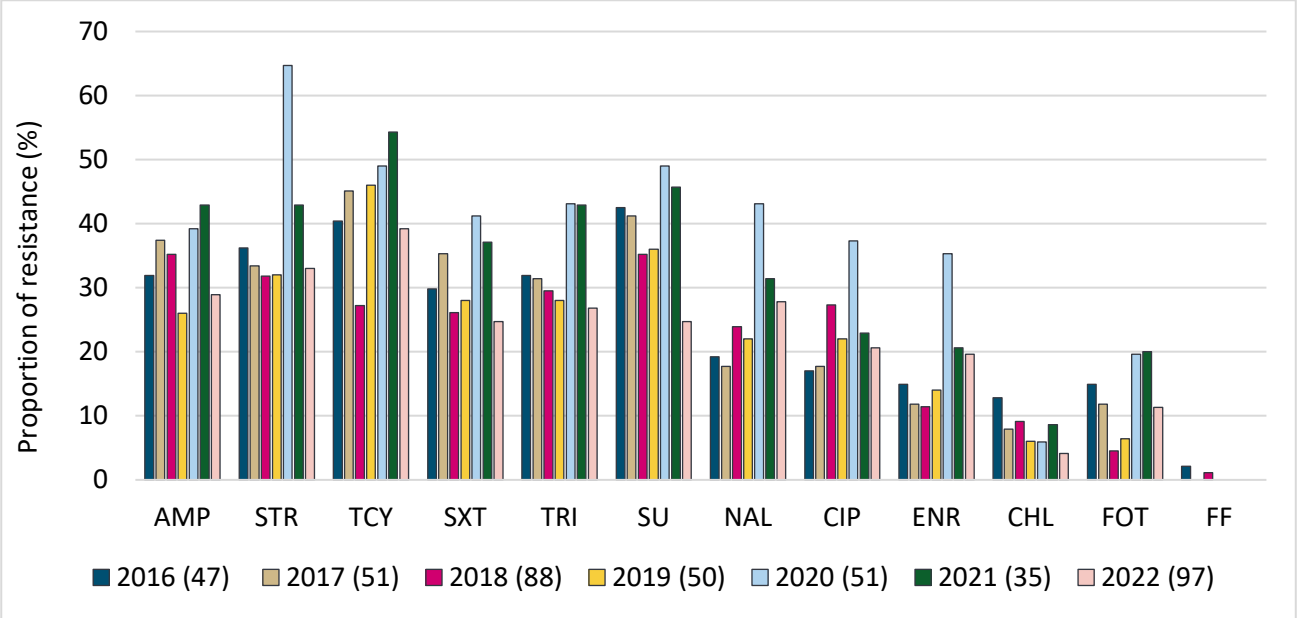

***Figure 12**. Resistance to tested antibiotics in 2016–2022, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

AMP, ampicillin; STR, streptomycin, TCY, tetracycline; SXT, trimethoprim-sulfamethoxazole; TRI, trimethoprim, SU, sulfamethoxazole; NAL, nalidixic acid; CIP, ciprofloxacin; ENR; enrofloxacin; CHL, chloramphenicol; FOT, cefotaxime; FF, florfenicol

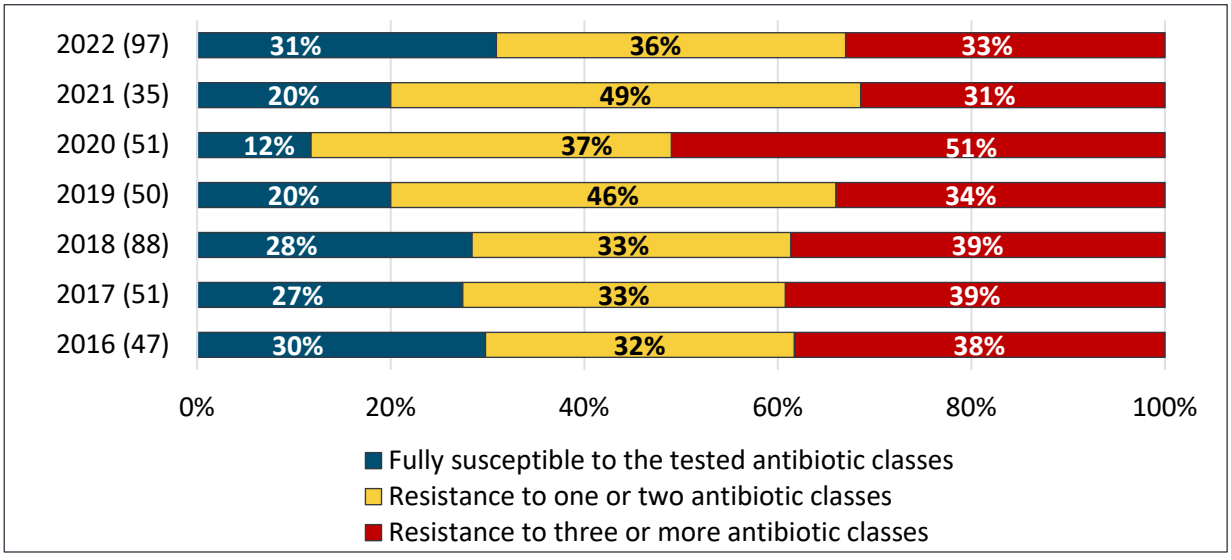

***Figure 13**. The proportions of multidrug resistant E. coli isolates from porcine enteritis in 2016–2022, epidemiological cut-off values used. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides, aminopenicillins, amphenicols, fluoroquinolones, 3rd generation cephalosporins, polymyxins, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

Table 7. *Distribution of MICs for Escherichia coli from porcine enteritis in 2022 (n=97). 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	28.9	20.8–38.6							1.0	36.1	30.9	3.1	3.1	6.2	19.6					
Cefotaxime	11.3	6.5–19.2			34.0	46.4	8.2	4.1	7.2											
Ceftazidime	2.0	0.6–7.2					81.4	7.2	9.3	1.0	1.0									
Chloramphenicol	4.1	1.6–10.1									50.5	43.3	2.1	1.0	3.1					
Ciprofloxacin	20.6	13.8–29.7	53.6	10.3	15.5	4.1	8.2	5.2			3.1									
Colistin	1.0	0.2–5.6							95.9	3.1	1.0									
Enrofloxacin	19.6	12.9–28.6			64.9	15.5	6.2	7.2	3.1		3.1									
Florfenicol	0.0	0.0-3.8									56.7	41.2	2.1							
Gentamicin	0.0	0.0-3.8						85.6	13.4	1.0										
Nalidixic acid	27.8	19.9–37.5									66.0	6.2	6.2	5.2	4.1	12.4				
Streptomycin	33.0	24.4–42.8									37.1	26.8	3.1	6.2	26.8					
Sulfamethoxazole[1]	24.7	17.2–34.2										66.0	8.2	1.0					1.0	23.7
Tetracycline	39.2	30.1–49.1							22.7	38.1					5.2	18.6	15.5			
Trimethoprim	26.8	19.0–36.4					49.5	13.4	7.2	3.1	1.0	4.1		21.6						
Trim/sulfa[2]	20.6	13.8–29.7						75.3	4.1		1.0	19.6								

Bold vertical lines indicate current (4.7.2023) 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] No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (dashed vertical line) for resistance monitoring purposes. [2] Differs from EUCAST ECOFF (double vertical line), concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20.

4.2 *Actinobacillus pleuropneumoniae* from respiratory and joint diseases of pigs

A. pleuropneumoniae is the most important respiratory pathogen in growing pigs in Finland. Sometimes it causes also joint infections. In 2022, 22 isolates from 14 farms were tested for antibiotic susceptibility. All obtained isolates were included. Clinical breakpoints (CLSI, 2020) were used to evaluate decreased susceptibility (Table 8). In 2022, a larger proportion of isolates had MIC between susceptible and resistance for oxytetracycline than before (31.8%). Otherwise, no significant changes in the MICs for the tested substances can be seen between 2016 and 2022. Each year the number of tested isolates has been rather small.

Table 8. *Distribution of MICs for Actinobacillus pleuropneumoniae from pigs in 2022 (n=22).*

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	0.0-14.9		59.1	31.8	4.5	4.5						
Ceftiofur	0.0	0.0-14.9		95.5	4.5								
Penicillin[1]	4.5	0.8-21.8	18.2	36.4	31.8	9.1				4.5			
Oxytetracycline	0.0	0.0-14.9			68.2	31.8							
Tiamulin	0.0	0.0-14.9							31.8	68.2			
Tulathromycin	0.0	0.0-14.9							4.5	36.4	54.5	4.5	

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

[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 2022. With these breakpoints, 16% of the isolates were resistant against tiamulin (compared to 0% in 2021), 16% (22% in 2021) against tylosin, 24% (22% in 2021) against lincomycin and 12% (22% in 2021) against tylvalosin (Table 9). Resistance in *B. pilosicoli* has mostly been at moderate level from 2015 to 2022 but the number of isolates tested each year has been small.

Table 9. *Distribution of MICs for Brachyspira pilosicoli from pigs in 2022 (n=25).*

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			83.3	8.3		4.2	4.2							
Lincomycin					60.0	8.0	8.0	8.0	4.0	12.0				
Tiamulin		72.0	8.0		4.0			16.0						
Tylosin							28.0	32.0	8.0	4.0	12.0		4.0	12.0
Tylvalosin				16.0	24.0	32.0	16.0					12.0		
Valnemulin	70.8	8.3	8.3	4.2	8.3									

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, 2020) were used to evaluate decreased susceptibility. All tested isolates were susceptible to ceftiofur and florfenicol.

Histophilus somni isolates, obtained from 18 farms, were fully susceptible in 2022 (Table 10). Between 2016 and 2020, decreased susceptibility was detected only against oxytetracycline (from 7% to 11%) but the resistant isolates have all originated from the same calf-rearing farm. *H. somni* was not isolated from this farm in 2021 and 2022.

Table 10. *Distribution of MICs for Histophilus somni from bovine respiratory disease in 2022 (n=19).*

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	0.0–16.8		100									
Enrofloxacin	0.0	0.0–16.8	100										
Florfenicol	0.0	0.0–16.8		100									
Oxytetracycline	0.0	0.0–16.8			94.7	5.3							
Penicillin	0.0	0.0–16.8	94.7	5.3									
Tulathromycin	0.0	0.0–16.8				5.3	21.1	26.3	42.1	5.3			

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.

In 2022, *Pasteurella multocida* isolates were obtained from 126 farms and on 117/126 (93%) of these farms, isolates were fully susceptible. Majority (92%) of *P. multocida* isolates investigated were fully susceptible, with 12 isolates being resistant to oxytetracycline (originating from 7 farms) and one isolate to penicillin. Intermediate susceptibility to tulathromycin was not noted in one isolate. Since 2016, resistance

has been low overall among *P. multocida* from bovine respiratory diseases (Figure 14). Resistance has most commonly been detected against oxytetracycline with a proportion between one and eight percent. The MIC distributions of different antibiotics for *P. multocida* isolated in 2022 are shown in Table 11.

Table 11. *Distribution of MICs for Pasteurella multocida from bovine respiratory disease in 2022 (n=179).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	0.0	0.0–2.1		99.4	0.6								
Enrofloxacin	0.0	0.0–2.1	100										
Florfenicol	0.0	0.0–2.0		50.8	49.2								
Oxytetracycline	6.7	3.9–11.4			68.7	9.5	15.1			6.7			
Penicillin	0.6	0.1–3.1	96.6	2.8						0.6			
Tulathromycin	0.0	0.0–2.1				45.8	35.2	16.2	1.1	1.1	0.6		

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.

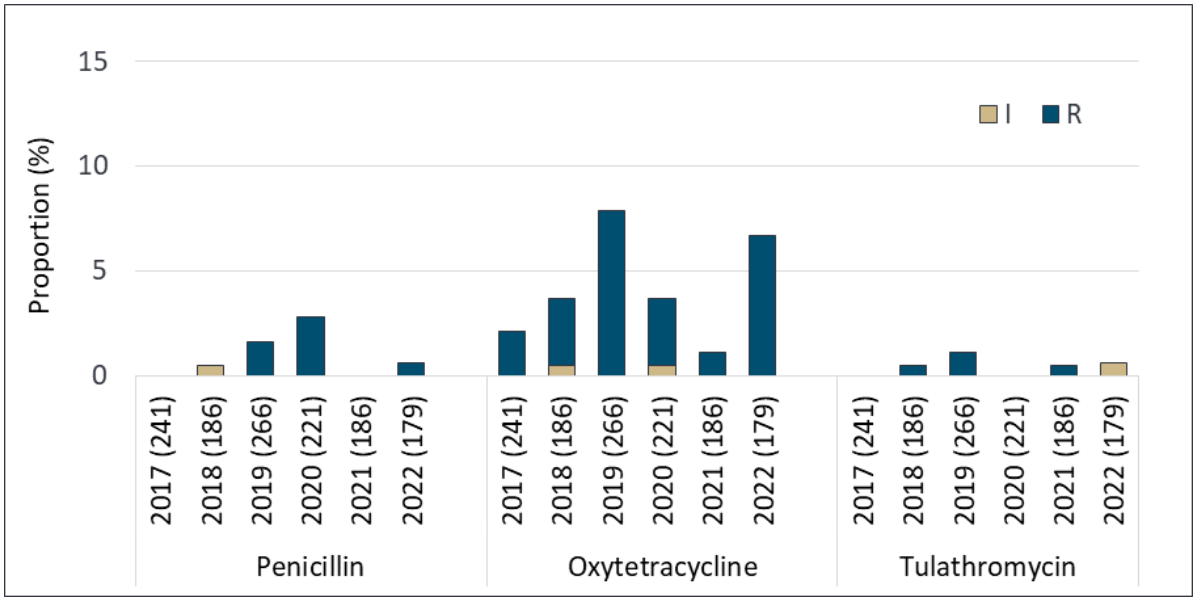

Figure 14. *Proportion (%) of Pasteurella multocida from bovine respiratory disease not susceptible to penicillin, oxytetracycline and tulathromycin in 2017–2022. The number of isolates tested each year are in brackets.*

In 2022, *Mannheimia haemolytica* isolates were obtained from 46 farms and isolates were fully susceptible on 74% of these farms. This is roughly the same as the previous year (78%). None of the isolates were resistant to more than one antibiotic. Only one oxytetracycline resistant and two penicillin resistant isolates (all from separate farms) were isolated in 2022. Altogether, isolates from nine farms had intermediate susceptibility to penicillin while no isolates had intermediate susceptibility to oxytetracycline. It seems that

the proportion of isolates with intermediate susceptibility to penicillin has increased since 2019, while the total proportion of non-susceptible isolates (isolates tested resistant or intermediate) has remained stable in recent years (Figure 15). The MIC distributions of different antibiotics for *M. haemolytica* isolated in 2022 are shown in Table 12.

Table 12. *Distribution of MICs for Mannheimia haemolytica from bovine respiratory disease in 2022 (n=48).*

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
			0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	0.0	0.0–7.4		100									
Enrofloxacin	0.0	0.0–7.4	100										
Florfenicol	0.0	0.0–7.4			8.3	91.7							
Oxytetracycline	2.1	0.4–10.9			60.4	35.4	2.1			2.1			
Penicillin	4.2	1.2–14.0	29.2	47.9	18.8	4.2							
Tulathromycin	0.0	0.0–7.4					35.4	64.6					

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.

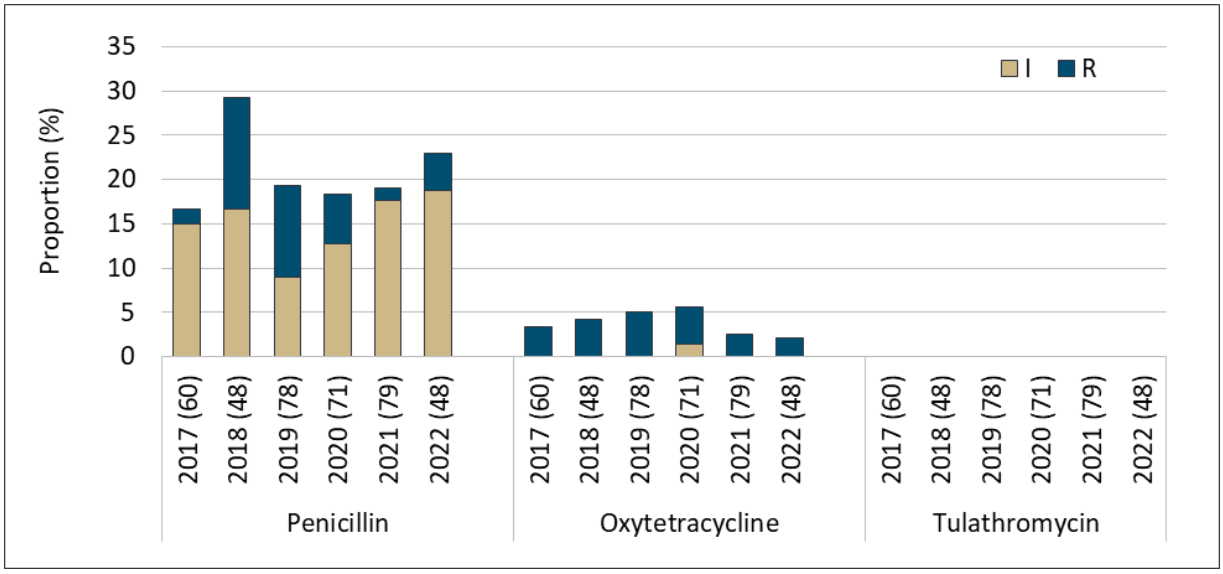

Figure 15. *Proportion (%) of M. haemolytica from bovine respiratory disease not susceptible to penicillin, oxytetracycline and tulathromycin in 2017–2022. The number of isolates tested each year are in brackets.*

4.5 *Escherichia coli* from colibacillosis in broilers

Colibacillosis infections in broilers and broiler parents are not treated with antibiotics in Finland. While there was a colibacillosis outbreak in the spring of 2021, no similar outbreaks were noted in 2022 although cases were quite frequent. In 2022, 100 strains were isolated from colibacillosis cases representing 72 different farms and 95 different sample submission.

Table 13. *Distribution of MICs for Escherichia coli from colibacillosis in 2022 (n=100).*

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	22.0	15.0–31.1								23.0	49.0	6.0			22.0					
Cefotaxime	0.0	0.0–3.7			44.0	54.0	2.0													
Ciprofloxacin	3.0	1.0–8.5	63.0	30.0	4.0	2.0	1.0													
Colistin	0.0	0.0–3.7							100											
Sulfamethoxazole[1]	8.0	4.1–15.0										65.0	25.0	2.0						8.0
Tetracycline	12.0	8.0–19.8							13.0	50.0	20.0	5.0				11.0	1.0			
Trimethoprim	4.0	1.6–9.8					16.0	52.0	27.0	1.0	1.0	1.0	1.0	1.0						

Bold vertical lines indicate current (4.7.2023) 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]No EUCAST ECOFF is available, therefore, a cut-off value of >64 µg/mL is used (dashed vertical line) for resistance monitoring purposes.

Based on epidemiological cut-off values, resistance to trimethoprim, sulfamethoxazole, and tetracycline remained low (Table 13, Figure 16). Ampicillin resistance in 2022 was markedly higher compared to 2021. This may be due to results being skewed by the ampicillin susceptible outbreak strain in 2021. As in previous years (2018–2021), no resistance against 3rd generation cephalosporins was found in 2022. Long term variation in susceptibility is difficult to assess due to the very low number of isolates prior to 2021.

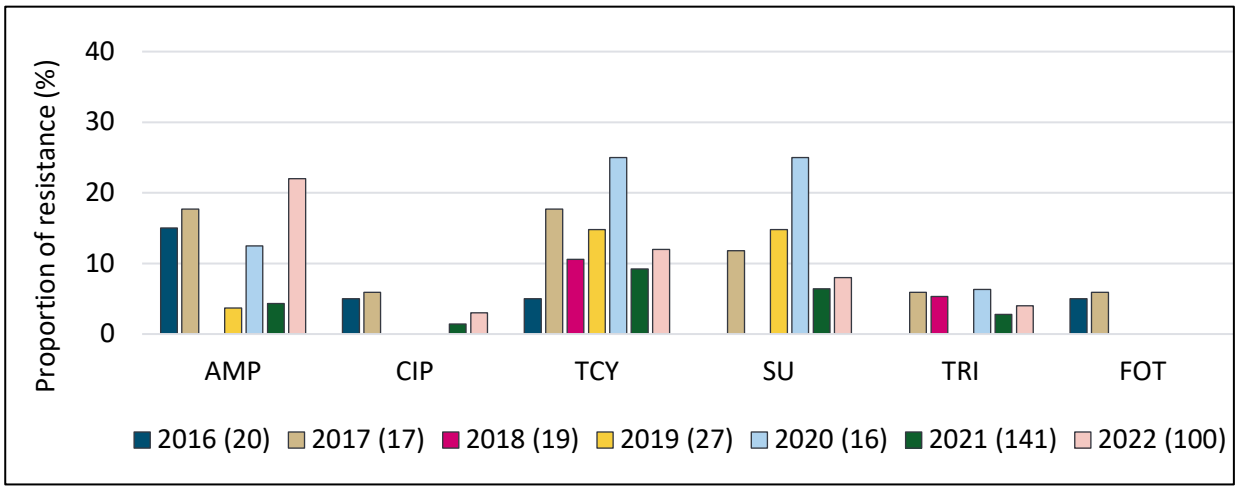

***Figure 16**. Antibiotic resistance (%) in E. coli from colibacillosis in the years 2016–2022, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

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

4.6 *Staphylococcus aureus* from tenosynovitis in broilers

Staphylococcus aureus from broiler tenosynovitis cases were isolated from post-mortem samples submitted to the Finnish Food Authority. All obtained *S. aureus* isolates were included. Ten isolates from seven broiler parent flocks were studied. All isolates were susceptible to the reported antibiotics (Table 14). None of the isolates were beta-lactamase producers or MRSA. Tenosynovitis is occasionally treated with antibiotics in broiler parent flocks. Production flocks have not been treated with antibiotics since 2010 (Animal Health ETT, 2023).

***Table 14.** Distribution of MICs for Staphylococcus aureus from tenosynovitis in broilers in 2022 (n=10).*

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	0.0–27.8								100				
Penicillin[1]	0.0	0.0–27.8	90.0	10.0										
Tetracycline	0.0	0.0–27.8					100							
Trim/sulfa[2]	0.0	0.0–27.8			100									

Bold vertical lines indicate current (4.7.2023) 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

Antimicrobial resistance figures from companion animal (dogs and cats) and horse pathogens were collected from the Clinical Microbiology Laboratory of the Veterinary Teaching Hospital, University of Helsinki. Antimicrobial resistance has been previously reported for the combined proportion of resistant and intermediate isolates. For the preceding 4-5 years, when possible, statistics were now re-evaluated from original data, presenting proportions of intermediate and resistant isolates separately, which may cause minor variations in results compared to previously reported results. The reporting period covers January 2017 – December 2022 and includes solely bacterial isolates derived from clinical infections. Screening specimens for multiresistant bacteria (MRSA, MRSP, ESBL) were omitted from the analysis. Approximately 30% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 70% 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

Antimicrobial resistance level in *S. aureus* of dogs, cats and horses was low (Figure 17), except for penicillin (not shown in figure). In 2022, 60% of the *S. aureus* isolates produced penicillinase, while the corresponding proportion varied between 67 and 69%in 2018–2021. Non-susceptibility to clindamycin increased markedly in 2022 compared to previous years, being almost 9% in 2022.

Oxacillin resistance (indicating the presence of MRSA among *S. aureus* isolates) during the monitoring period remained generally at a low level, being around 4,5% in 2022. Of the five MRSA isolates detected in clinical infections in 2022, four isolates were from dogs and one from a horse. Two of the canine isolates were of *spa* type t034, one of *spa* type t172, and one of t1255. All the canine MRSA isolates originated from superficial surgical site infections. The equine isolate was of *spa* type t5354 (from milk sample). This isolate was not related to the Equine Teaching Hospital (University of Helsinki) MRSA outbreak isolates.

5.1.1 Significance of resistance in *S. aureus*

S. aureus is a part of the normal microbiome of the skin and mucous membranes of cats and horses, as well as 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 have zoonotic potential and may thus have an impact on public health.

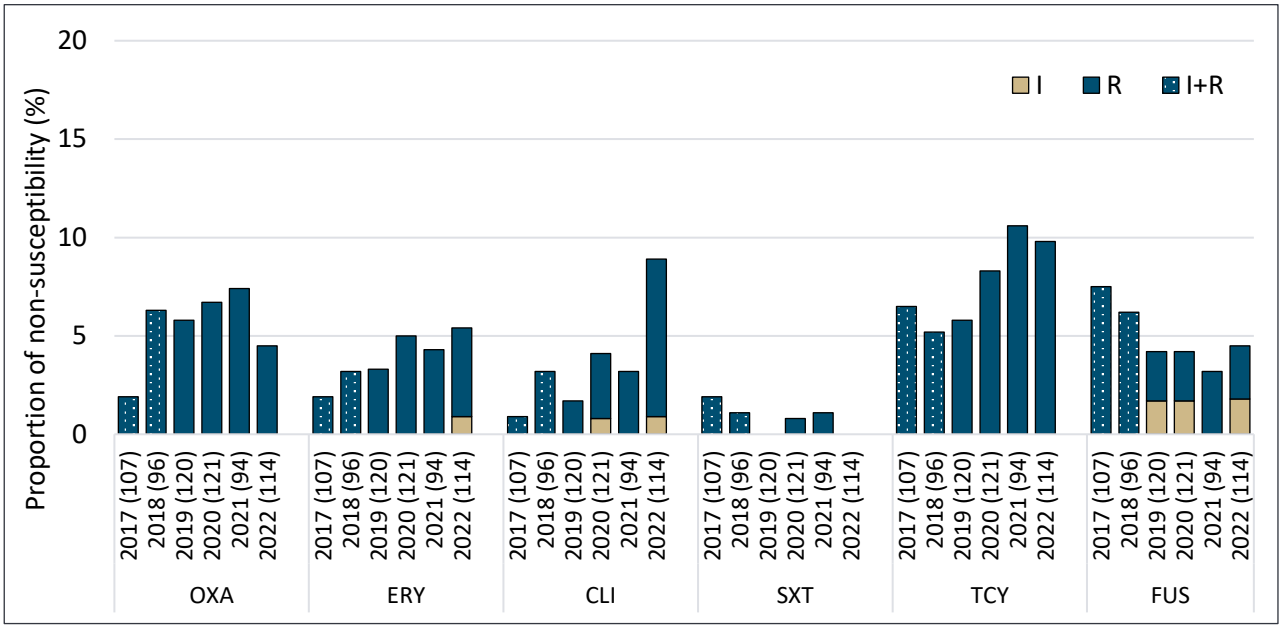

***Figure 17**. Antibiotic non-susceptibility (%) in canine, feline, and equine S. aureus in 2015–2022. The number of isolates tested each year are in brackets. In 2022, 79 isolates originated from dogs, 15 from cats, and 20 from horses.*

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 resistance, decreased slightly from 2021 (5.1% in 2022, 5,7% in 2021), maintaining the level it has been on since 2018. The proportion has declined drastically during the last seven years: in 2016, the proportion of MRSP was as high as nearly 14% of all *S. pseudintermedius* isolates (see previous FINRES-Vet reports and Figure 18). Penicillinase production remained high as out of the 614 tested *S. pseudintermedius* isolates in 2022, 86% produced penicillinase, which is a larger proportion than among *S. aureus* isolates ($p<0.0001$).

The overall non-susceptibility distribution of *S. pseudintermedius* isolates remained similar in 2022, when compared to the few previous years (Figures 18 and 19). Macrolide (erythromycin) and lincosamide (clindamycin) non-susceptibility increased from 2021, being approximately 22% for both antimicrobial classes in 2022. 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 25%.

No resistance to amikacin was detected in clinical infection isolates of *S. pseudintermedius* in 2022.

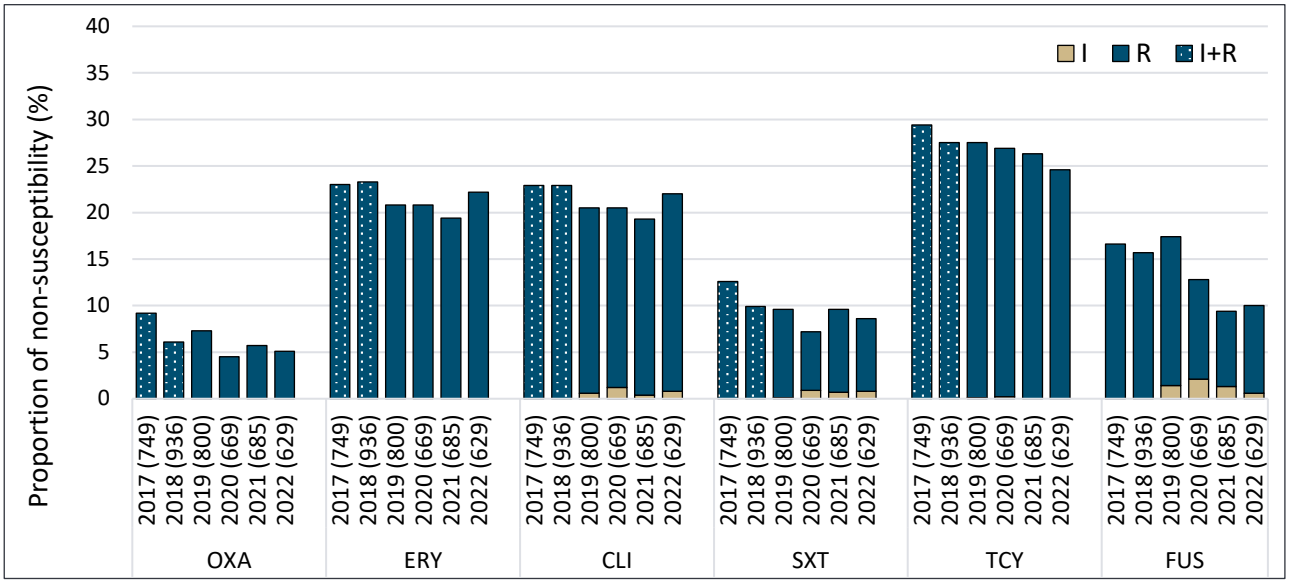

***Figure 18**. Antibiotic non-susceptibility (%) for primary antimicrobial agents in canine S. pseudintermedius isolates in 2017–2022. The numbers of isolates tested each year are in brackets.*

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

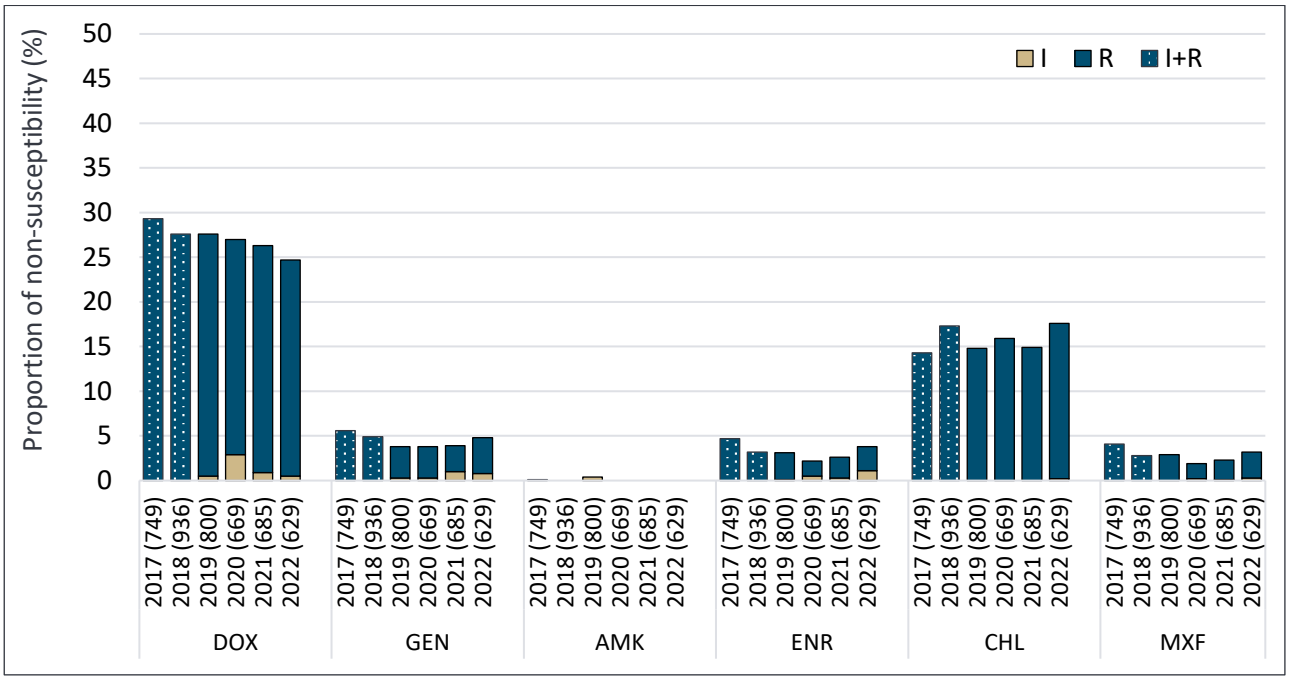

***Figure 19**. Antibiotic non-susceptibility (%) for secondary antibiotics in canine S. pseudintermedius isolates in 2017–2022. The number of isolates tested each year are in brackets.*

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

5.2.1 Significance of resistance in *S. pseudintermedius*

S. pseudintermedius belongs to the normal microbiome of the skin and mucous membranes in dogs and rarely in cats. It is an opportunistic pathogen that most often causes skin or wound infections and occasionally urinary infections. The proportion of oxacillin resistance and thus the proportion of MRSP among *S. pseudintermedius* isolates has decreased since the last report. The current overall resistance status remains fair as well. 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, 86% 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 amoxicillin and penicillin. *S. pseudintermedius* is a moderately common urinary pathogen in dogs. 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.

5.3 *Escherichia coli* from dogs and cats

Resistance figures for canine and feline *E. coli* are presented in Figure 20 and 21, respectively. Non-susceptibility for both ampicillin and amoxicillin-clavulanic acid decreased in canine *E. coli* isolates compared to 2021. It may be that 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 also decreased slightly compared to 2021. Amoxicillin-clavulanic acid non-susceptibility was analogous for both cats and dogs. More specifically, in 2022 24% of all canine *E. coli* isolates were classified as resistant to ampicillin, and around 3% were resistant to amoxicillin-clavulanic acid, which could implicate that aminopenicillins still could be used in most cases of infection, if treated with an increased dosage. This could be applied at least to urinary bladder infections, as beta-lactams concentrate well in urine, and *E. coli* is the most common pathogen in canine and feline urinary bladder infections.

Enrofloxacin non-susceptibility in canine *E. coli* isolates increased compared to 2021, but remained on a low level, having been roughly 5% in 2022 (3% were resistant). Trimethoprim-sulfamethoxazole resistance in canine and feline *E. coli* fluctuated through the monitoring period, having been 11% in dogs and 1% in cats in 2022.

In 2022, 2.6% of canine *E. coli* were resistant to cefpodoxime, indicating reduced susceptibility to third generation cephalosporins (Figures 20 and 22). The proportion of AmpC-producing isolates decreased to 1%, and for ESBL-producers the number remained below 1% (0.6% in 2022, having been 0.4% in 2021 and 2020) (Figure 22). However, the proportion of isolates resistant to cefpodoxime in feline *E. coli* increased from 2021 (4.1% in 2022, 2.7% in 2021).

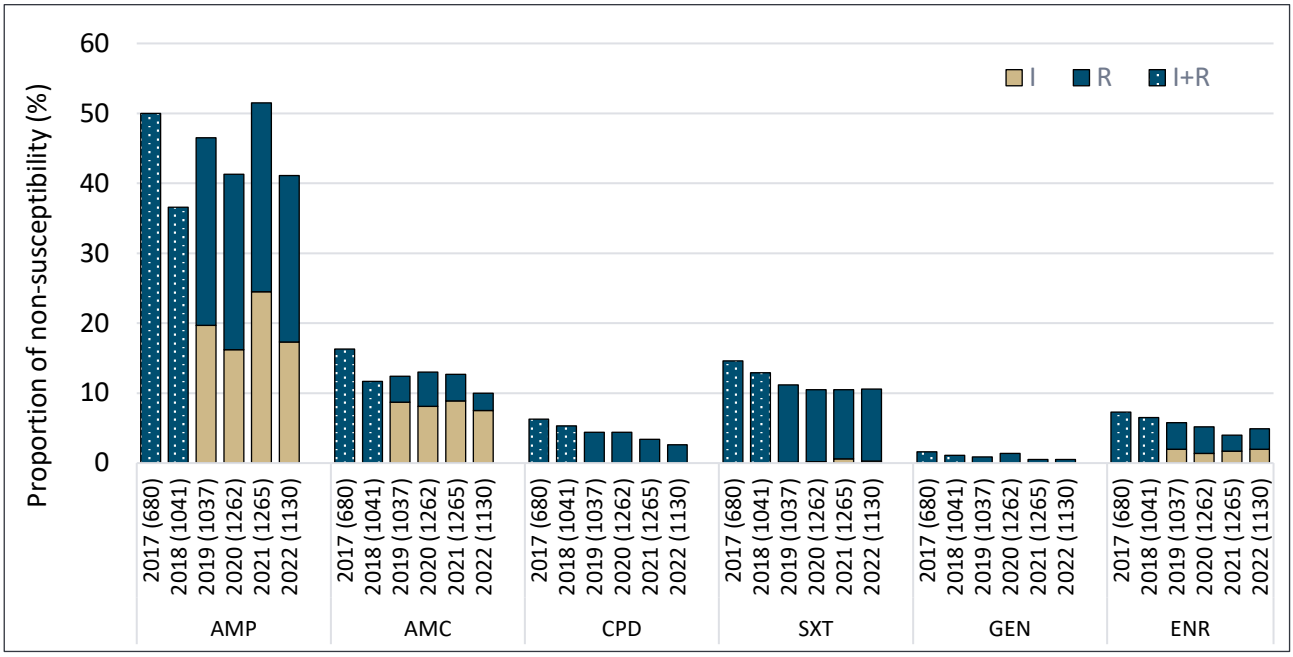

Figure 20. Antibiotic non-susceptibility (%) in canine E. coli in 2017–2022. The number of isolates tested each year are in brackets.

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

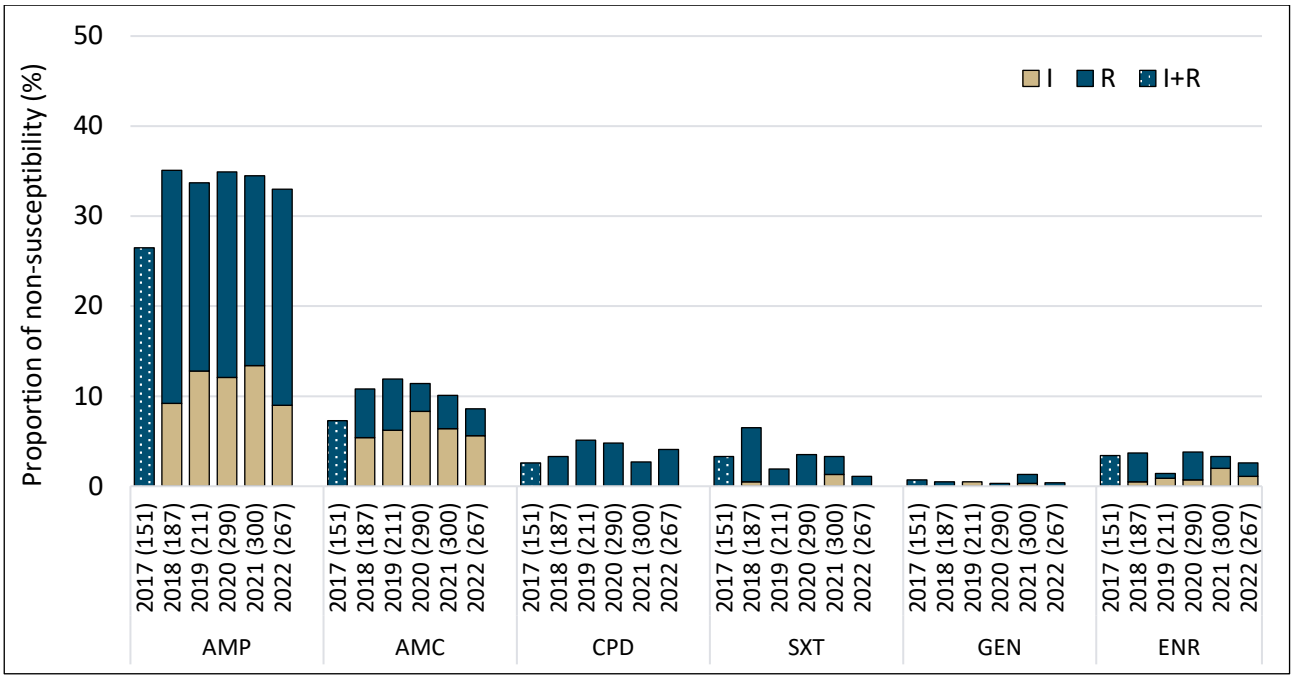

***Figure 21**. Antibiotic non-susceptibility (%) in feline E. coli in 2017–2022. The number of isolates tested each year are in brackets.*

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

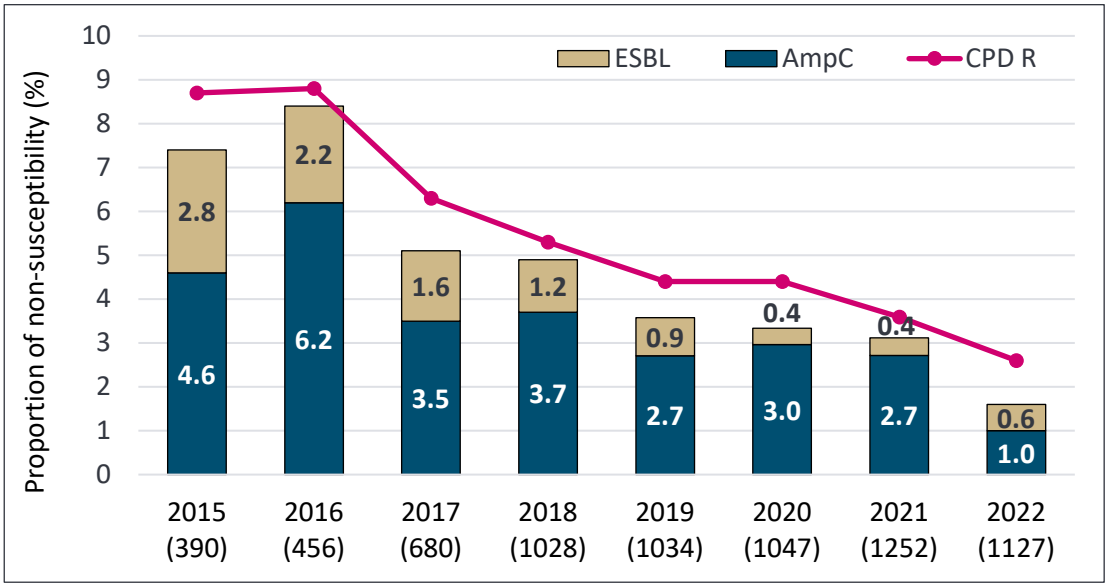

Figure 22. *The proportion of isolates with reduced susceptibility to cefpodoxime (CPD), and the proportion of ESBL and AmpC positive isolates in canine E. coli in 2015–2022. The number of isolates tested for CPD each year are in brackets. Only CPD resistant isolates were tested for phenotypic ESBL/AmpC production.*
CPD, cefpodoxime; AmpC and ESBL, extended-spectrum beta-lactamases

5.4 Streptococci from dogs and horses

In 2022, all tested canine *Streptococcus canis* isolates were susceptible to penicillin. One isolate was resistant and one intermediate to trimethoprim-sulfamethoxazole (Figure 23). Resistance against this clinically important antimicrobial was absent in 2019 but has recurred since in low ratios. Macrolide (erythromycin) non-susceptibility remained around 10% as in 2021. Clindamycin non-susceptibility decreased slightly, while non-susceptibility to tetracycline decreased from around 61% in 2021 to 54% in 2022. It is worth noting that from the beginning of 2019 *S. canis* isolates from *otitis externa* specimens were not tested for systemic-only antimicrobials (e.g. penicillin, trimethoprim-sulfamethoxazole, erythromycin and clindamycin). Thus, the number of tested isolates for tetracycline has been greater ever since.

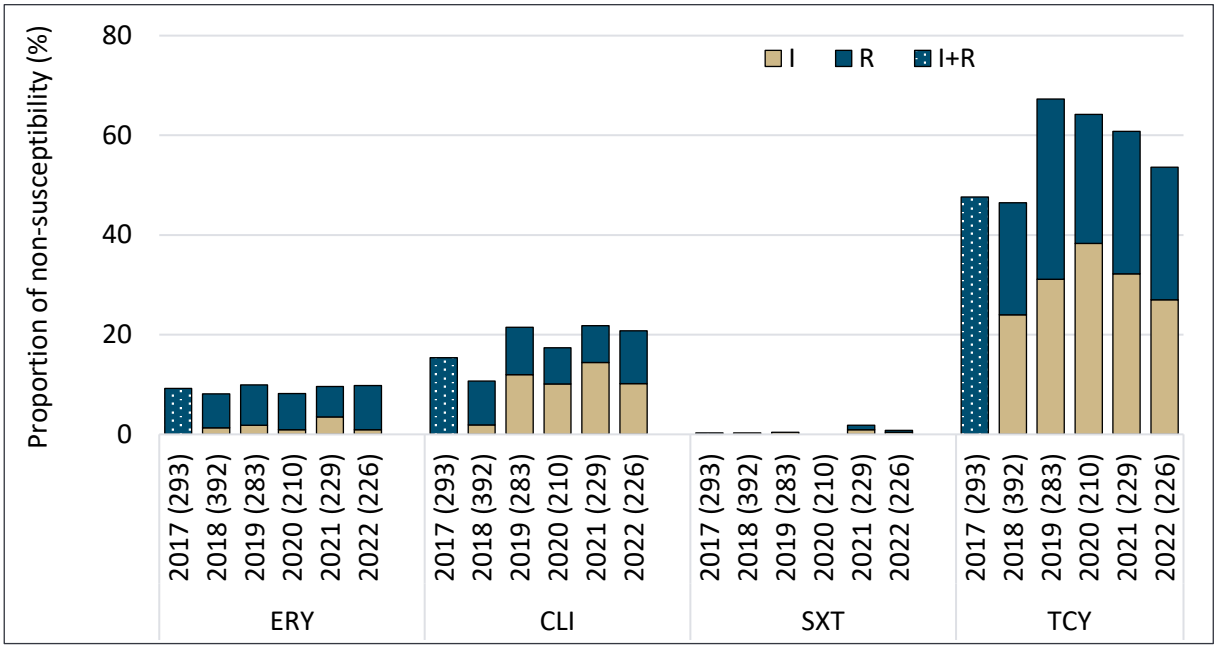

***Figure 23**. Antibiotic non-susceptibility (%) in canine S. canis isolates in 2017–2022. The number of isolates tested each year are in brackets (isolates tested for tetracycline susceptibility: 351 isolates in 2019, 258 in 2020, 273 in 2021, and 252 in 2022).*

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

In 2022, 43 *Streptococcus equi* ssp. *zooepidemicus* isolates were found in equine infection specimens. All isolates were susceptible to penicillin. It is noteworthy that almost 10% of the isolates were non-susceptible to trimethoprim-sulfamethoxazole (three isolates classified as resistant in 2022; Figure 24). The development of resistance to this antibiotic substance has to be monitored carefully due to its importance in the treatment of many equine infections.

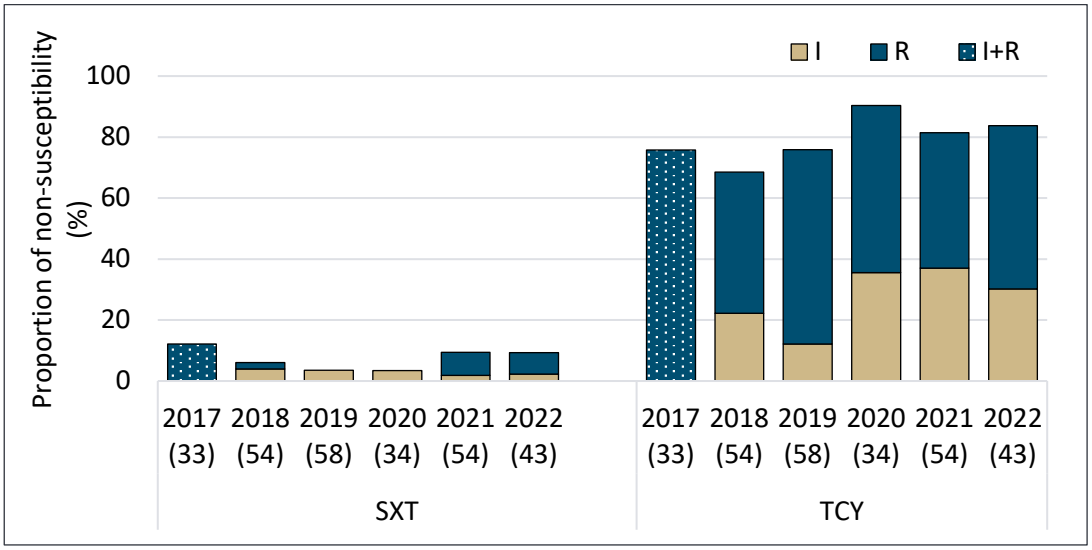

***Figure 24**. Antibiotic non-susceptibility (%) in equine S. equi ssp. zooepidemicus isolates in 2017–2022. The number of isolates tested each year are in brackets.*

SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline

5.5 *Pseudomonas aeruginosa* from dogs

In 2022, 46 canine clinical infection isolates of *P. aeruginosa* were tested. A clear increase in gentamicin non-susceptibility compared to previous years was observed, being around 11% in 2022 (Figure 25). Three isolates were classified as resistant to gentamicin and two isolates as intermediate. Amikacin non-susceptibility also increased in 2022 up to 4%, while two isolates were classified resistant. Tobramycin resistance was detected for the first time, with two resistant isolates (4%). No resistance to colistin was detected. Most of the isolates (91%) were susceptible to ciprofloxacin. For enrofloxacin, 24% of the isolates were classified as resistant (78% non-susceptible).

Meropenem non-susceptibility was also detected, with three phenotypically resistant and three intermediate isolates. Different *bla*OXA genes, indicative of beta-lactamase resistance, were found in whole genome sequencing in these isolates. However, it remains unclear whether these genes are the cause of meropenem-resistance in *P. aeruginosa* species.

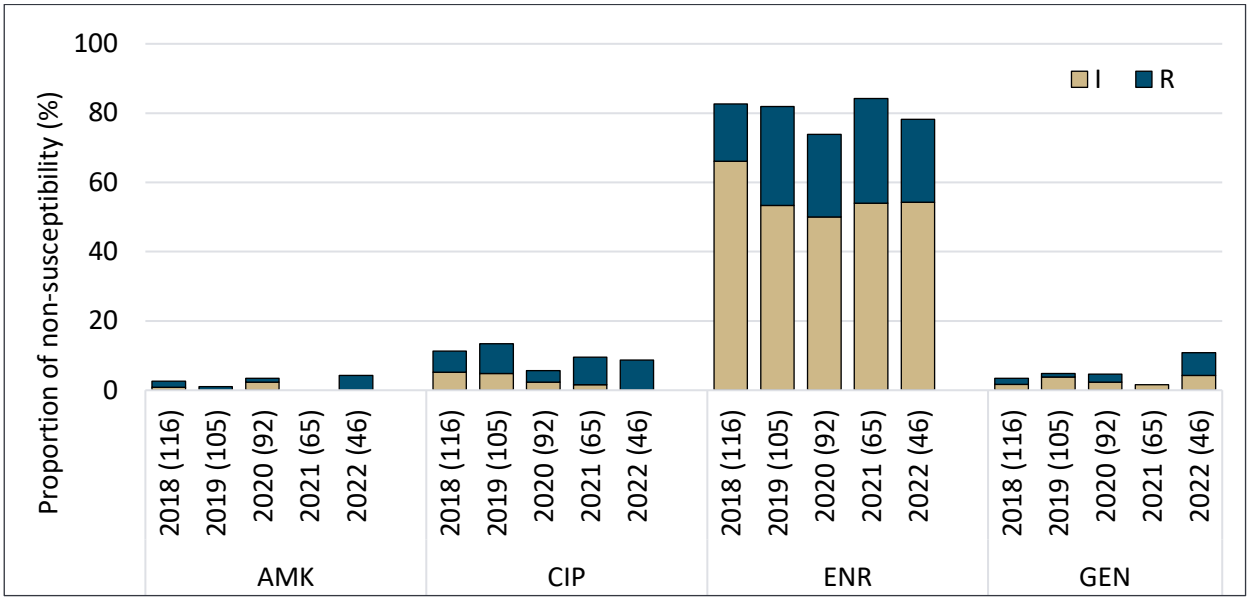

Figure 25. *Antibiotic non-susceptibility (%) in canine P. aeruginosa isolates in 2018–2022. The number of isolates tested each year are in brackets.*

AMK, amikacin; CIP, ciprofloxacin; ENR, enrofloxacin; GEN, gentamicin

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 are presented. Details of the sampling and laboratory analysis are described in Appendix 3.

6.1 Indicator *E. coli* from broilers

In 2022, a total of 170 isolates from broilers were tested for antibiotic susceptibility. Resistance was overall low (Table 15) and the majority (80%) of the isolates was fully susceptible to the tested antibiotics (Figure 27). The most common resistance traits detected were against tetracycline (10%), ciprofloxacin (8%), nalidixic acid (8%), sulfamethoxazole (7%), and trimethoprim (5%) (Table 15). Altogether, 3.5% of the isolates were multidrug resistant (Table 16). ESBL or AmpC isolates were not detected.

Resistance levels have been quite stable since 2008 (Figure 26). The proportion of isolates resistant to ampicillin increased from 4% to 14% between 2011 and 2018 but decreased in 2020 (4%) and 2022 (3.5%). Ciprofloxacin resistance was around 5% between 2014 and 2020 but increased to 7.6% in 2022. After a drop in 2018, the proportion of isolates resistant to tetracycline has risen back to 10%.

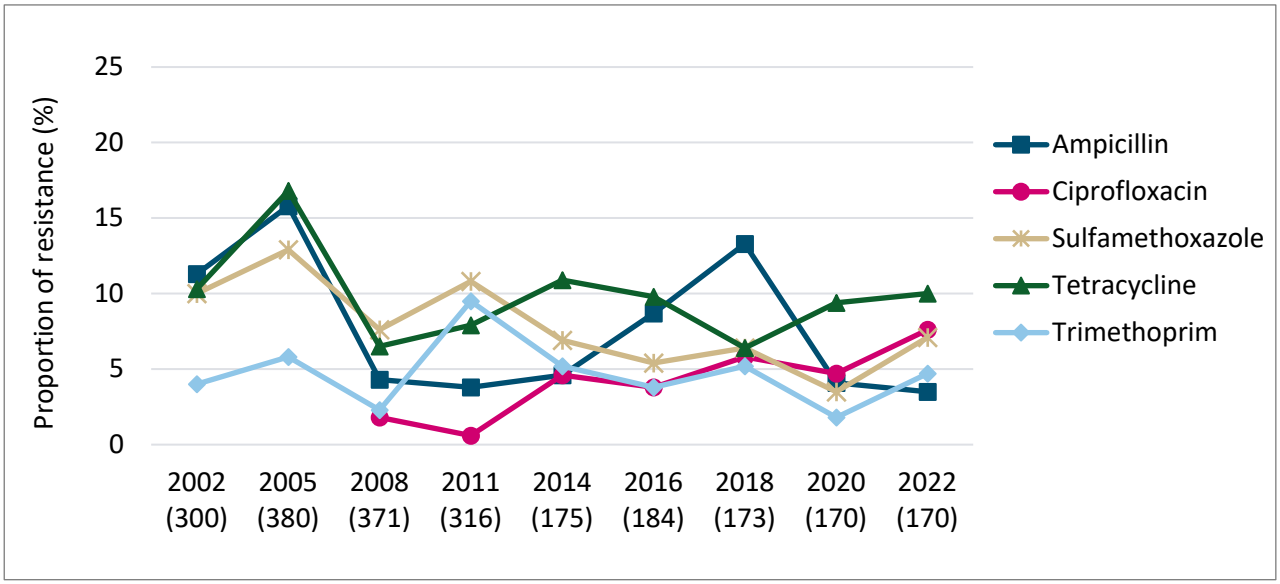

***Figure 26**. Resistance in indicator E. coli from broilers to selected antibiotics in 2002–2022. The number of isolates tested each year is in brackets.*

Table 15. *Distribution of MICs for indicator Escherichia coli in broilers in 2022 (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	>512
Amikacin	0.0	0.0–2.2									98.8	1.2							
Ampicillin	3.5	1.6–7.5							1.8	28.8	58.8	7.1			3.5				
Azithromycin[1]	0.0	0.0–2.2								4.1	29.4	55.3	11.2						
Cefotaxime	0.0	0.0–2.2					100												
Ceftazidime	0.0	0.0–2.2					92.9	7.1											
Chloramphenicol	0.0	0.0–2.2										96.5	3.5						
Ciprofloxacin	7.6	4.5–12.6	88.2	3.5	0.6	1.2	3.5	1.8				1.2							
Colistin	0.0	0.0–2.2							99.4	0.6									
Gentamicin	1.2	0.3–4.2						74.7	22.9	1.2				1.2					
Meropenem	0.0	0.0–2.2		98.8	1.2														
Nalidixic acid	7.6	4.5–12.6									91.8	0.6			4.1	3.5			
Sulfamethoxazole[2]	7.1	4.1–11.9										47.1	41.2	4.7					7.1
Tetracycline	10.0	6.3–15.4								85.9	4.1				10.0				
Tigecycline	0.0	0.0–2.2					97.6	2.4											
Trimethoprim	4.7	2.4–9.0					45.9	35.9	12.9	0.6				4.7					

Bold vertical lines indicate current (4.7.2023) 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.

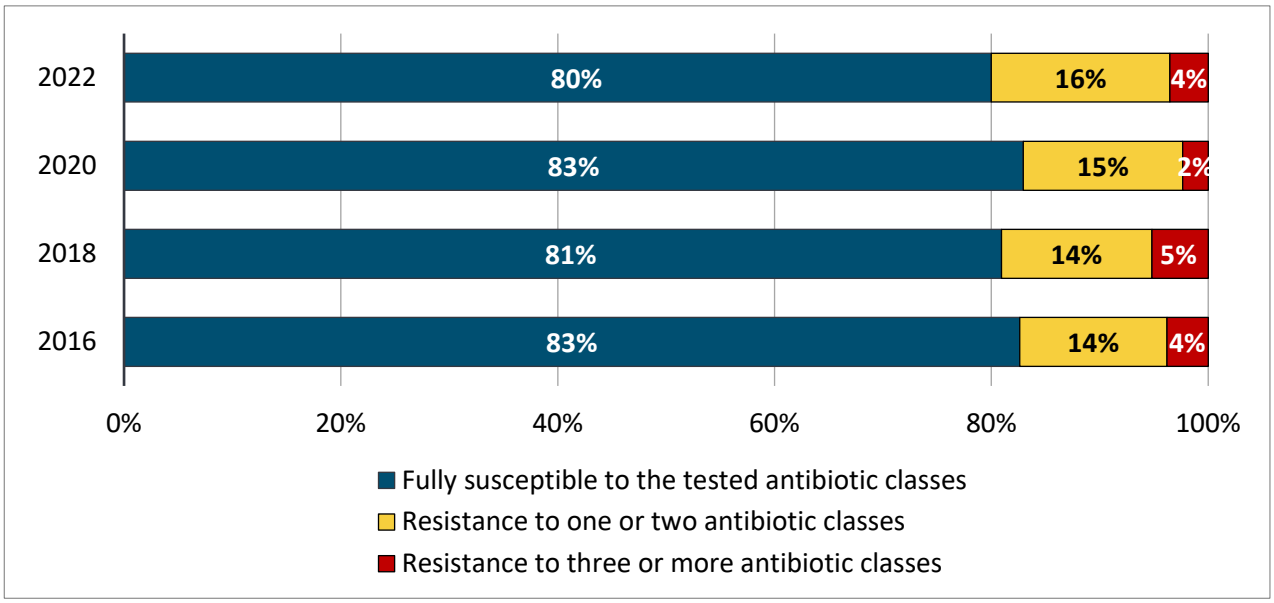

***Figure 27**. Antibiotic susceptibility of indicator E. coli from broilers at slaughter in Finland between the years 2016 and 2022. The numbers of tested isolates each year are the same as in Figure 30. Antibiotic classes included in the analysis: aminoglycosides, beta-lactams, glycylcyclines, phenicols, polymyxins, quinolones, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

***Table 16**. Resistance profiles of multidrug resistant indicator E. coli from broilers in 2016, 2018, 2020 and 2022.*

Resistance profile	Nr of isolates in each year			
	2016	2018	2020	2022
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		1
AMP-SU-TRI-CIP-NAL	1			
GEN-TET-SU-CIP-NAL				2
AMP-SU-CIP-NAL	1	3	1	
AMP-TET-SU-TRI	1	3		1
AMP-CIP-NAL-TET			1	
TET-SU-TRI	3		1	1
AMP-SU-TRI		1	1	1
Sum	**7**	**9**	**4**	**6**

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

References

Animal Health ETT (Eläinten terveys ETT), 2023. Use of antibiotics in broiler meat production in Finland 2017-2022. Accessed 25.10.2023.

Clinical Laboratory Standards Institute, CLSI 2018. Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals, 5th ed. Approved Standard VET01.

Clinical Laboratory Standards Institute, CLSI 2020. Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals. 5th ed. CLSI Supplement VET01S.

Clinical Laboratory Standards Institute, CLSI 2020b. Performance Standards for Antimicrobial Susceptibility Testing, Approved Standard, 30th ed. Approved Standard M100.

Commission Implementing Decision (EU) 2020/1729. Official Journal of the European Union, L387/8, 19.11.2020.

European Food Safety Authority, EFSA 2010. Antimicrobial resistance in zoonotic and indicator bacteria from animals and food in the European Union in 2008. EFSA Journal, 261 pp. Available at EFSA's web page.

EMA 2011: Trends in the sales of veterinary antimicrobial agents in nine European countries; Reporting period 2005-2009: EMA > Veterinary regulatory > Overview > Antimicrobial resistance > European Surveillance of Veterinary Antimicrobial Consumption > Previous reports. Accessed 9.10.2023.

EMA 2019; Categorisation of antibiotics in the European Union; Answer to the request from the European Commission for updating the scientific advice on the impact on public health and animal health of the use of antibiotics in animals (EMA/CVMP/CHMP/682198/2017). Accessed 9.10.2023.

EMA, 2022. European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, 2022. 'Sales of veterinary antimicrobial agents in 31 European countries in 2021' (EMA/795956/2022). Accessed 9.10.2023.

ECDC, EFSA ja EMA 2017: Joint Scientific Opinion on a list of outcome indicators as regards surveillance of antimicrobial resistance and antimicrobial consumption in humans and food-producing animals. Accessed 9.10.2023.

Evira, 2016. In Finnish: Mikrobilääkkeiden käyttösuositukset eläinten tärkeimpiin tulehdus- ja tartuntatauteihin. In Swedish: Användningsrekommendationer för mikrobläkemedel mot de viktigaste inflammationssjukdomarna och smittsamma sjukdomarna hos djur. In English: Evira 2018. Recommendations for the use of antimicrobials in the treatment of the most significant infectious and contagious diseases in animals. Accessed 25.10.2023.

FIFUR, 2023. FIFUR Statistics 2023. Accessed 25.10.2023.

Finnish Food Authority, 2023a. Finnish Food Authority Publications; Animal diseases in Finland. Accessed 12.10.2023.

Finnish Food Authority, 2023b. Manufacture of medicated feed for fur animals in 2007–2022 (in Finnish). Turkiseläinten lääkerehujen valmistus 2007–2022. Accessed 9.10.2023.

Finnish Food Authority, 2023c. Milestones in prudent use of antimicrobials in animals in Finland. Accessed 9.10.2023.

Finnish Food Authority Open data. Accessed 9.10.2023.

Finnish Medicines Agency, Medicine search. Accessed 12.10.2023.

Finnish Study Group for Antimicrobial Resistance (FiRe), 2009. Bakteerin lääkeherkkyyden määrittäminen kiekkomenetelmällä, versio 6. Accessed 3.11.2022.

Murakami K, Minamide W, Wada K, Nakamura E, Teraoka H and Watanabe S., 1991. Identification of methicillin-resistant strains of staphylococci by polymerase chain reaction. *J. Clin. Microbiol*. 29: 2240-2244.

Natural Resources Institute Finland, 2023. Statistics . Accessed 9.10.2023.

WHO, 2019. Critically Important Antimicrobials for Human Medicine (6th revision): Ranking of medically important antimicrobials for risk management of antimicrobial resistance due to non-human use. Accessed 9.10.2023.

Appendix 1. Population statistics

The population of food-producing animals (as PCU) is presented in Table 17. The number of livestock and farms, and the production of meat and milk in Finland are presented in Tables 18–21 (Source: Luke, the Natural Resources Institute Finland).

***Table 17**. Population of food-producing animals as PCU (1000 tonnes) by species in 2013–2022.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cattle	224	226	229	228	222	220	213	207	205	199
Pigs	170	163	163	161	153	142	142	145	145	141
Poultry	67	68	70	73	76	82	83	85	86	87
Sheep and goats	11	11	13	13	13	13	12	12	11	11
Horses	30	30	30	30	30	30	30	30	30	30
Fish	14	13	15	14	15	14	15	15	14	16
TOTAL, PCU	516	512	520	520	508	500	496	494	491	485

***Table 18.** Number of livestock (in thousands) in Finland in 2013–2022.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Dairy cows	283	285	285	282	275	271	262	260	254	248
Suckler cows	57	58	59	59	60	60	60	62	64	65
Cattle > 1 year[1]	271	268	264	258	261	252	247	235	238	240
Calves < 1 year	300	303	307	310	297	299	288	290	289	281
TOTAL, Cattle	912	914	915	909	893	882	858	846	844	834
Boars and sows[2]	NA	NA	127	117	106	104	102	100	100	92
Pigs > 3 months and < 8 months	NA	NA	579	575	536	508	495	496	504	477
Piglets < 3 months	NA	NA	537	542	494	477	475	490	503	492
TOTAL, pigs	1 308	1 245	1 243	1 235	1 136	1 089	1 072	1 087	1 108	1 061
Laying hens	3 432	3 645	3 595	3 599	3 746	3 985	3 900	3 812	3 729	3 866
Chicks	858	714	662	748	509	608	647	566	796	665
Broilers	6 861	7 341	7 827	8 272	8 047	8 781	9 112	8 507	8 499	8 901
Turkeys	274	292	246	260	292	299	263	268	287	283
Other poultry[3]	555	584	597	566	543	468	438	424	520	641
TOTAL, poultry	11 981	12 577	12 927	13 445	13 136	14 140	14 360	13 577	13 831	14 356

[1] Heifers and bulls in total. [2] Includes boars, sows and young breeding animals. [3] Including broiler parent hens, cockerels, turkey parents, 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 19. *Number of farms in Finland in 2013–2022.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cattle farms	13 416	12 885	12 389	11 791	11 175	10 530	9 851	9 301	8 787	8 211
Pig farms	1 637	1 486	1 337	1 240	1 102	1 027	963	918	864	798
Poultry farms	1 207	1 299	1 310	1 300	1 280	1 243	1 172	1 201	553	475

Source: OFS: Luke, Number of livestock.

Table 20*. The production of meat and fish (million kg) in Finland in 2013–2022.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Beef[1]	81	83	86	87	86	87	88	87	86	84
Pork[1]	195	186	192	190	182	169	171	176	176	170
Poultry[1]	111	113	117	125	129	135	139	145	147	147
Total	387	383	397	403	397	391	398	408	409	401
Fish[2]	14	13	15	14	15	14	15	15	15	16

[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 21. *The production of milk in Finland in 2013–2022.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Milk production; per animal (litres)	7 977	8 201	8 323	8 406	8 534	8 650	8 810	9 038	8 924	8 888
Total milk production (million litres)	2 260	2 330	2 365	2 359	2 336	2 328	2 305	2 336	2 247	2 193

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

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

Table 22. *Overall sales of veterinary antibiotics in Finland in 2013–2022, kg active ingredient.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tetracyclines	2 389	2 576	2 250	2 010	2 268	2 218	2 677	1 830	1 780	1 248
Amphenicols	121	84	80	87	104	112	117	109	124	110
Penicillin G and V	4 442	4 231	4 058	3 544	3 771	3 805	3 705	3 824	3 918	3 661
Aminopenicillins	1 314	1 374	1 498	1 438	1 160	1 020	1 011	934	1 012	826
Cloxacillin	82	91	65	63	45	39	33	39	48	36
1st gen. cephalosporins[1]	793	727	605	513	355	284	227	184	169	129
3rd gen. cephalosporins	8	8	7	3	1	0.5	0.2	0.2	0.2	0.2
Sulfonamides and trimethoprim	3 129	2 893	2 445	2 460	2 216	1 870	2 119	1 646	1 980	1 685
Macrolides	456	521	596	517	408	411	221	192	190	106
Lincosamides	155	189	165	120	297	184	197	61	56	54
Aminoglycosides	103	101	93	87	73	61	59	42	27	21
Fluoroquinolones	105	113	94	99	80	81	66	70	69	60
Pleuromutilins	43	44	30	23	14	10	3	2	0	0
Others								0	5	7
Total sales	**13 140**	**12 954**	**11 987**	**10 964**	**10 790**	**10 095**	**10 435**	**8 933**	**9 378**	**7 979**

[1] *Sales in 2014 corrected for one product.*

Table 23. *Sales of injectable veterinary antibiotics in Finland in 2013–2022, kg active ingredient.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tetracyclines	558	552	640	686	671	642	741	644	602	540
Amphenicols	26	17	6	13	26	15	23	24	25	16
Penicillin G	4 270	3 981	3 781	3 230	3 538	3 564	3 479	3 565	3 692	3 699
Aminopenicillins	379	416	473	453	338	286	279	229	271	215
1st gen. cephalosporins	0	0	0	5	1	1	0	0	0	0
3rd gen. cephalosporins	8	8	7	3	1	0.5	0.2	0.2	0.2	0.2
Sulfonamides and trimethoprim	344	358	373	322	317	286	292	252	213	202
Macrolides	12	12	15	19	13	10	9	9	7	5
Lincosamides	24	26	26	25	19	18	19	24	21	23
Aminoglycosides	12	15	13	14	12	10	10	12	7	6
Fluoroquinolones	83	90	72	78	63	66	50	56	55	47
Total sales	**5 718**	**5 475**	**5 406**	**4 849**	**4 999**	**4 899**	**4 902**	**4 815**	**4 893**	**4 538**

Tables 24A and 24B. *Sales of orally administered veterinary antibiotics (premixes, oral solutions, oral powders and oral pastes) and sales of veterinary antibiotic tablets by class in Finland 2013-2022, kg active ingredient.*

24A. *Sales of orally administered products excluding veterinary antibiotic tablets 2013-2022, kg active ingredient. Others = 1st generation cephalosporins and fluoroquinolones.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tetracyclines	1 830	2 024	1 610	1 324	1 597	1 575	1 936	1 186	1 173	735
Amphenicols	95	67	74	74	78	97	94	85	99	94
Penicillin V	47	122	147	190	100	105	94	118	92	53
Aminopenicillins	45	50	123	82	44	47	22	45	19	48
Sulfonamides and trimethoprim	2 657	2 411	2 072	2 138	1891	1557	1 813	1 382	1 724	1 458
Macrolides	444	510	581	498	395	402	212	183	182	101
Lincosamides	75	109	91	48	238	131	146	< 1	< 1	< 1
Pleuromutilins	43	44	30	23	14	10	3	2	0	0
Others	4	4	3	2	2	2	2	2	1	< 1
Total sales	**5 241**	**5 341**	**4 731**	**4 379**	**4 359**	**3 925**	**4 322**	**3 002**	**3 290**	**2 490**

24B. *Sales of orally administered veterinary antibiotic tablets 2013-2022, kg active ingredient. Others = tetracyclines, aminoglycosides and imidazole derivatives.*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Aminopenicillins	878	897	894	894	769	681	707	656	721	562
1st gen. cephalosporins	762	701	584	491	339	272	218	180	168	129
Sulfonamides and trimethoprim	127	124	0	0	8	27	14	12	44	25
Macrolides	55	54	48	46	39	34	33	37	34	31
Fluoroquinolones	22	22	22	21	16	15	15	14	14	13
Others	76	70	62	54	41	32	29	8	10	15
Total sales	**1 919**	**1 869**	**1 611**	**1 507**	**1 212**	**1 060**	**1 016**	**908**	**991**	**775**

Tables 25A and 25B. *Sales of intramammaries for veterinary use in Finland 2013-2022, kg active ingredient*

25A. *Intramammaries for lactation phase*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Penicillin	88	93	88	80	86	91	87	93	90	87
Aminopenicillins	8	8	7	7	6	5	3	4	1	1
Cephalexin	27	22	18	15	13	9	8	2	0	0
Cloxacillin	39	41	31	29	19	18	15	25	23	19
Aminoglycosides	0	0	0	0	0	0	0	0	0	0
Macrolides	0	0	0	0	0	0	0	0	0	0
Total lactation phase	**162**	**164**	**144**	**131**	**123**	**123**	**113**	**124**	**114**	**108**

25A. *Intramammaries for dry cow period*

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Penicillin	37	35	41	44	47	45	45	49	45	36
Aminopenicillins	4	3	2	2	3	1	0	0	0	0
Cephalexin	0	0	0	0	0	0	0	0	0	0
Cloxacillin	43	50	35	34	26	21	18	14	26	17
Aminoglycosides	16	15	18	19	20	20	20	21	19	15
Total dry cow	**100**	**104**	**96**	**100**	**97**	**87**	**83**	**85**	**90**	**68**

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 systems.

Campylobacter were isolated from broilers by the industry in association with the Finnish *Campylobacter* programme for broilers. Samples were taken from healthy animals at the slaughterhouses covering approximately 99% of all broilers slaughtered in Finland. Between 1 June and 31 October, every slaughtered broiler production batch was sampled, and between 1 November and 31 May, the frequency is set annually depending on production volume. From each epidemiological unit (flock), a caecal sample was taken from ten animals. All isolates (one isolate per flock) were included in the antibiotic susceptibility testing.

Animal pathogens

Clinical isolates originated from diagnostic submissions or post-mortem examinations done in the laboratories of the 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 the Finnish Food Authority. All obtained *S. aureus* isolates were included from the study period. *A. pleuropneumoniae* isolates originated mostly from post-mortem investigations of lungs most likely from pigs with respiratory disease. Occasional findings from joints were also included in the analysis. 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.

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

Indicator *E. coli* was isolated from broiler caecal samples in 2022. From the same samples, ESBL/AmpC and carbapenemase producing *E. coli* were screened. The samples from broilers (n=301) originated from healthy animals at slaughter between February and December. Sampling was evenly distributed throughout the monitoring period. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. Samples were collected at the three biggest slaughterhouses accounting for >99% of all broilers slaughtered in Finland. From each epidemiological unit (flock), one sample consisted of caeca taken from ten animals. 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 were randomly selected for susceptibility testing from all isolates available at the laboratory. 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 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) broiler meat (n=300) and turkey meat (n=151) were collected at retail between January and December in 2022. Sampling was evenly distributed throughout the study period and 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 on 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 the Finnish Food Authority, in the Veterinary Bacteriology and Pathology Unit.

C. jejuni and *C. coli* from broilers were isolated at slaughterhouse laboratories and confirmed at the Finnish Food Authority, in the Microbiology Unit, according to ISO 10272-1:2017.

Animal pathogens

Isolation and identification of pathogens from food-producing animals was performed by accredited conventional culture and biochemical/MALDI-TOF methods at the Finnish Food Authority, in the Animal Health Diagnostic Unit.

Identification of pathogens from companion animals was performed 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

Caecal content was directly spread on Brilliance™ *E. coli*/coliform Selective Agar (Oxoid) and incubated overnight at 37°C. Typical 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

Broiler caecal samples (n=301) taken at slaughterhouses, fresh broiler meat (n=300) and turkey meat (n=151) samples taken at retail, were screened as part of the EU-wide monitoring based on Commission Implementing Decision (EU) 2020/1729 according to the latest 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 by analysing the liners from each imported flock as two pooled samples (liners from 5 transport boxes suspended in 3 liters of BPW).

Susceptibility testing

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

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

Bacteria from food-producing animals

The susceptibility testing of bacteria from food-producing animals was performed with broth microdilution method according to the Clinical and Laboratory Standards Institute (CLSI) standard VET01 5th ed (CLSI, 2018) using Sensititre™ (TREK Diagnostic Systems Ltd, United Kingdom) microtiter plates except for *Brachyspira* spp. for which 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). Penicillin susceptibility of *S. aureus* was based on beta-lactamase activity tested with Cefinase™ disks (Becton Dickinson, NJ, USA).

Susceptibility testing was performed at the Microbiology Unit and for *Brachyspira* spp. at the Veterinary Bacteriology and Pathology Unit. The current (4.7.2023) 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 26). When available, clinical breakpoints of the CLSI VET01S 5th ed document (CLSI, 2020) were used to evaluate clinical resistance in animal pathogens. For *Brachyspira* spp., no standardised breakpoints exist, and laboratory-specific breakpoints were used to evaluate clinical resistance.

Table 26. *Cut-off values (mg/L) for resistance used in this report. Values represent EUCAST epidemiological cut-offs (ECOFFs) (4.7.2023). 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*
Amikacin	>4[1]	>8		
Ampicillin	>4	>8		
Azithromycin	>16	>16[1]		
Cefotaxime	>0.5[1]	>0.25		
Cefoxitin				>4
Ceftazidime	>2	>1		
Chloramphenicol	>16	>16	>16	
Ciprofloxacin	>0.125	>0.06	>0.5	
Colistin	[2]	>2		
Enrofloxacin		>0.125		
Ertapenem			>0.125[1]	
Erythromycin			>4	
Florfenicol		>16		
Gentamicin	>2	>2	>2	
Meropenem	>0.125[3]	>0.06		
Nalidixic acid	>8	>8		
Streptomycin		>16		
Sulfamethoxazole	>256[3]	>64[3]		
Tetracycline	>8	>8	>1	>1
Tigecycline		>0.5		
Trimethoprim	>2[1]	>2		
Trimethoprim/ sulfamethoxazole[4]		>1[5]		>0.25[1]

[1] tentative EUCAST ECOFF, [2] EUCAST ECOFF not available, [3]EUCAST ECOFF not available, given cut-off value used for resistance monitoring purposes, [4]concentration of trimethoprim given, concentration ratio with sulfamethoxazole 1:20, [5]differs from ECOFF

Bacteria from companion animals

Susceptibility testing of bacteria isolated from companion animals was performed in the clinical microbiology laboratory of the Faculty of Veterinary Medicine with a disk diffusion technique with an available CLSI VET01 (5th ed) standard (CLSI, 2018). For all data, clinical breakpoints of the standard CLSI VET01S 5th ed (CLSI, 2020) was used to calculate non-susceptibility (intermediate and resistant) percentages. If veterinary breakpoints were not available, the breakpoints available in CLSI M100 30th ed (CLSI, 2020b) were used. An exception was the fusidic 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 Animal Health Diagnostic Unit of the 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 the *Brachyspira* susceptibility test, *Brachyspira hyodysenteriae* ATCC 31212 was used as a quality control strain.

The Animal Health Diagnostic Unit is accredited for isolation, identification and serotyping of *Salmonella*, and the Microbiology Unit and the Bacteriology laboratory in Seinäjoki using 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 an 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 2022

Table 27. *Salmonella enterica serovars isolated from the main food-producing animal species in Finland in 2022.*

Serotype	Nr of isolates	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	18	11	5	2	
monophasic *S.* Typhimurium	2		2		
S. Enteritidis	16	14	1	1	
S. Uganda	3		3		
S. Altona	2	2			
S. Derby	2		2		
S. Abony	1	1			
S. Havana	1	1			
S. Infantis	1	1			
S. Kentucky	1	1			
S. Konstanz	1	1			
S. Manhattan	1	1			
S. Mbandaka	1		1		
S. Montevideo	1		1		
S. Nuorikkala	1	1			
S. Onderstepoort	1	1			
S. Overschie	1	1			
S. ssp. IIIb (= diarizonae)	1	1			
Sum	**55**	**37**	**15**	**3**	**0**

FINNISH FOOD AUTHORITY

Ruokavirasto • Livsmedelsverket

ruokavirasto.fi
foodauthority.fi
livsmedelsverket.fi