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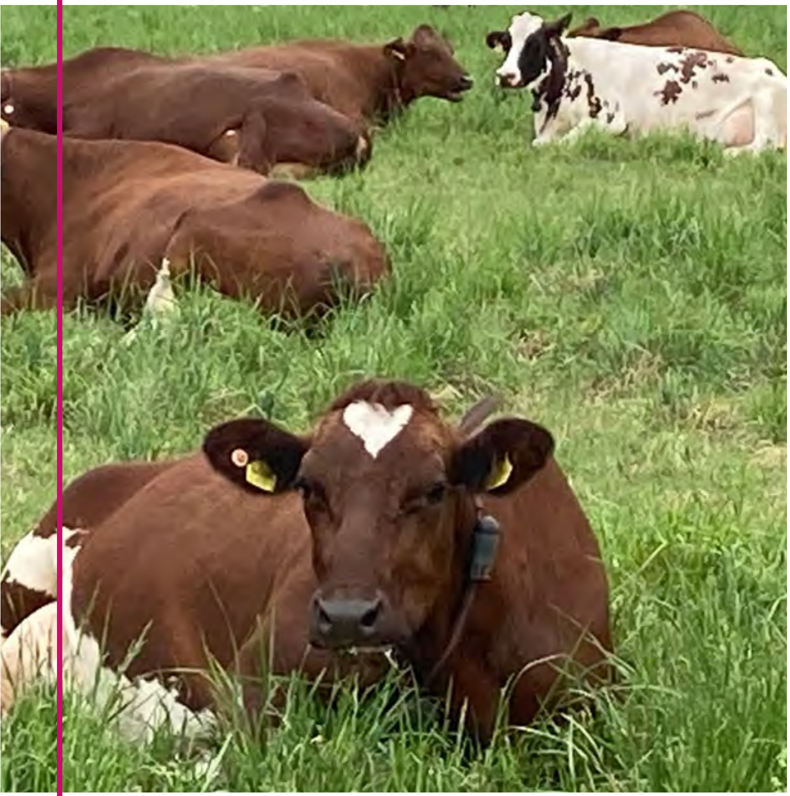
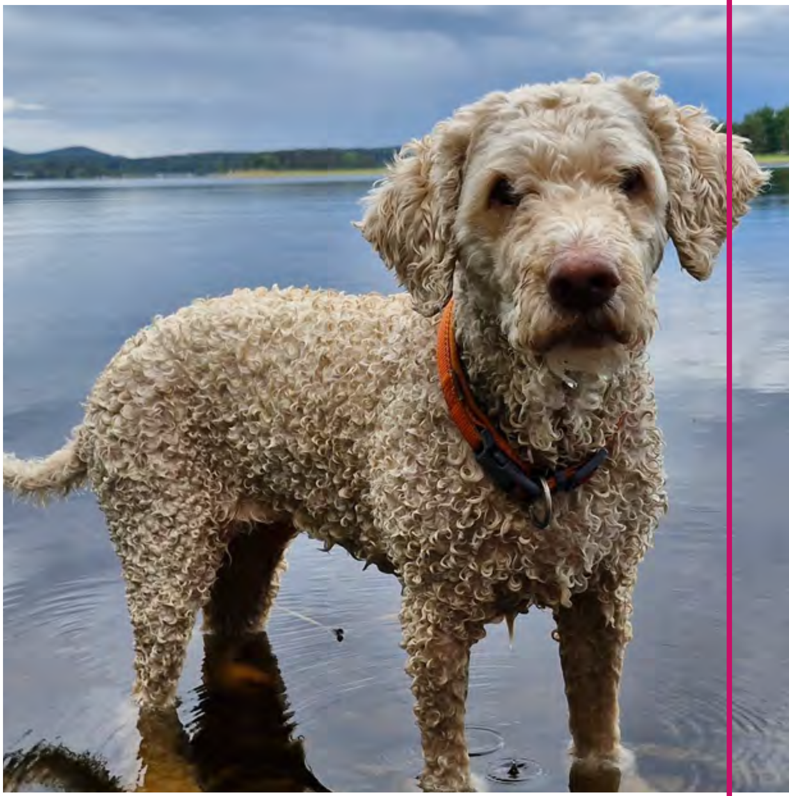
FINRES-Vet 2023

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

Finnish Food Authority publications 6/2024

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RUOKAVIRASTO
Livsmedelsverket • Finnish Food Authority

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

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Abstract

Sales of veterinary antibiotics for food-producing animals increased by 7% in 2023. The result was still the second 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. The largest increase in sales was noted for orally administered oxytetracyclines and sulfa-trimethoprim-combination. Sales of tablets for companion animals increased as well. Sales of injectable penicillin decreased but it 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 is detected more often. 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 in 2023. In campylobacter isolated from pigs at slaughter fluoroquinolone resistance has remained around 30% in the 2020s but the proportion of strains resistant to fluoroquinolones decreased between 2021 and 2023. The resistance situation among indicator *E. coli* from slaughtered pigs has remained good but the downward trend has stopped for some antibiotics. The prevalence of ESBL/AmpC-producing bacteria in slaughter pigs stayed at the same level as in 2021. No ESBL/AmpC-producing bacteria were detected in pork samples at retail and only minor proportion in beef (of foreign origin).

The resistance situation among pathogenic bacteria isolated from food-producing animals remained similar to 2023. 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. However, there is possibly an increasing trend in proportions of non-susceptible isolates to several antimicrobials, especially among staphylococci and *E. coli*.

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Tiivistelmä

Tuotantoeläinten määrään suhteutettu antibioottien myynti lisääntyi 7 % vuonna 2023. Tulos oli kuitenkin toiseksi matalin seurannan aloittamisen jälkeen. Valtaosa antibiooteista annettiin eläinyksilöille, ryhmälääkityksinä annettavien antiboottien osuus oli reilu neljännes. Eniten lisääntyi suun kautta annettavan tetrasykliinin ja sulfa-trimetopriimiyhdistelmän myynti. Myös seuraeläinten antibioottitablettien myynti lisääntyi. Injektiopenisilliinin myynti väheni, mutta se 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 edelleen suhteellisen hyvä. Joillakin bakteerilajeilla resistenssiä esiintyy yleisemmin, 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 2023 vain vähän. Teurassioista eristetyillä kampylobakteereilla fluorokinoloniresistenssi on 2020-luvulla pysynyt 30 %:n tuntumassa, mutta fluorokinoloneille resistenttien kantojen osuus väheni vuosien 2021 ja 2023 välillä. Teurassioista eristettyjen *E. coli* -indikaattoribakteerien resistenssitilanne on pysynyt hyvänä, mutta pitkään laskusuuntainen trendi on pysähtynyt joidenkin antibioottien osalta. ESBL/AmpC-bakteereiden esiintyminen suomalaisissa teurassioissa säilyi vuoden 2021 tasolla. Tuoreessa vähittäismyynnin sianlihassa ESBL/AmpC-bakteereita ei esiintynyt lainkaan ja tuoreessa naudanlihassa vain vähän (ulkomaista alkuperää olevassa naudanlihassa).

Tuotantoeläinten patogeenien resistenssitilanne pysyi samankaltaisena vuoteen 2023 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. Kuitenkin herkkyydeltään heikentyneiden kantojen osuuksissa oli nähtävissä mahdollista nousevaa suuntausta useilla antibiooteilla etenkin stafylokokki- ja *E. coli* -kannoilla.

Beskrivning

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Referat

Den proportionella försäljningen av antibiotika i förhållande till antalet produktionsdjur ökade med 7 % år 2023. Resultatet blev dock näst lägst sedan påbörjandet av uppföljningen. Största delen av antibiotikan gavs till djurindivider och drygt en fjärdedel var gruppläkemedel. Mest ökade försäljningen av oxytetracykliner och sulfa-trimetoprim-kombination som administreras oralt. Även försäljningen av antibiotikatabletter för sällskapsdjur ökade. Försäljningen av penicillin i injektionsform minskade, men var fortfarande den mest använda antibiotikan. 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 fortfarande relativt god i Finland. Hos vissa bakterier uppträder resistens oftare. 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 i 2023. För *Campylobacter* som isolerats från slaktsvin har fluorokinolonresistensen legat kvar på cirka 30 procent under 2020-talet, men andelen resistenta stammar mot fluorokinoloner minskade mellan 2021 och 2023. Resistenssituationen för *E. coli*-indikatorbakterier isolerade från slaktsvin har varit fortsatt god, men den nedåtgående trenden har avstannat för vissa antibiotika. Förekomsten av ESBL/AmpC-bakterier i finländska slaktsvin låg kvar på nivån 2021. Inga ESBL/AmpC-bakterier hittades bland svinkött i detaljhandeln och endast lite i nötkött (av utländskt ursprung).

Resistenssituationen för patogener i produktionsdjur förblev liknande jämfört med 2023. 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. Det finns ändå en möjlighet om en uppåtgående tendens i andelen av isolater med nedsatt känslighet, i synnerhet vid stafylokocker och *E. coli* -isolater.

Contents

Introduction

FINRES-Vet 2023 reports statistics on sales of veterinary antibiotics and antibiotic resistance in bacteria isolated from animals and food. This report covers the latest results from 2023 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 Veterinary Teaching Hospital (University of Helsinki) provides antibiotic susceptibility data from companion animals and horses.

In 2023, 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 also affected 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 are low. In 2023 the population corrected sales of antibiotics to food producing animals increased by 7%, but were second lowest ever reported. Narrow spectrum 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 2014 to 2023 continued to show a slight decrease. The number of all the species decreased. Even the number of poultry went down a little bit for the first time during the last ten years (Figure 1.1). 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 2014, the PCU has decreased by 9% from 512 to 467 (thousand tons).

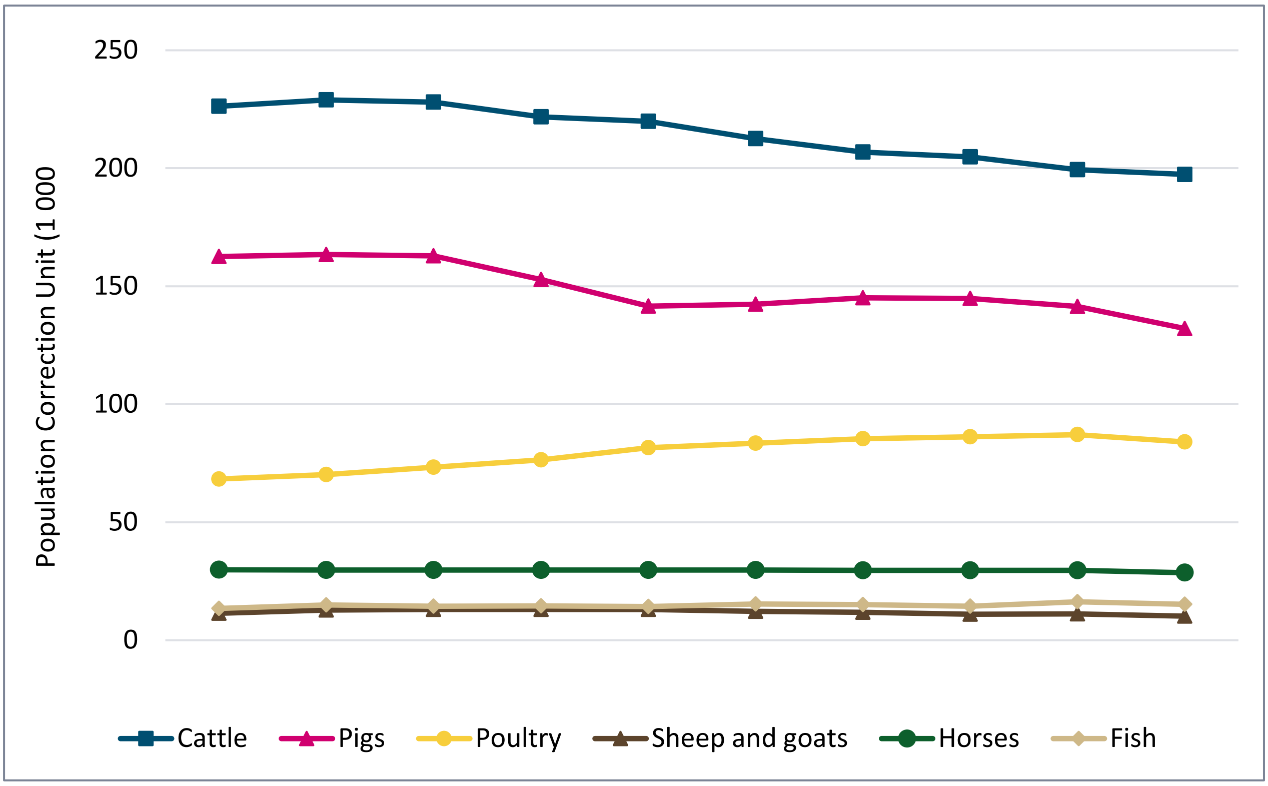

Figure 1.1. *Changes in food-producing animal population in Finland in 2014–2023, PCU (1 000 tonnes). Detailed data on the PCU of food-producing animals in a tabulated form is presented in Appendix 1.*

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 has changed quite a lot during the last decade (FIFUR, 2024). The number of cubs born was at its highest about 4.7 million animals in 2015 equaling to estimated 30 tonnes of live animals. Thereafter, a downward trend is seen. Decrease from 2022 to 2023 was 8% resulting in 1.2 million cubs born in 2023.

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 2014–2023 with a particular focus on 2023. For a review of data for 1995–2013, see the FINRES-Vet reports covering the corresponding years.

Data is collected in accordance with the protocol of the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. It covers also sales of veterinary antibiotics that are used on 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 2023, their proportion was approximately 8% 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 therefore 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 i.e. overall sales, sales of fluoroquinolones and 3rd generation cephalosporins (ECDC, EFSA and EMA, 2017). PCU adjusted data does not include tablets, as they are almost exclusively used in companion animals. Only estimates of the number of dogs and cats in Finland are available, and therefore sales of tablets cannot be adjusted to the population of companion animals, but are presented in a separate figure, as kg active ingredient.

1.2.2 Overall sales (kg active ingredient)

Overall sales of veterinary antibiotics in 2023 was 8 290 kg, which is the second lowest ever reported (Figure 1.2, Table A6. in Appendix 2). Sales increased by 4% from the all-time low in 2022. Increase was noted especially in sales of tetracyclines and sulfonamide-trimethoprim combination whereas sales of penicillin G continued to decrease. For population corrected sales see section 1.2.5. on EU-indicators.

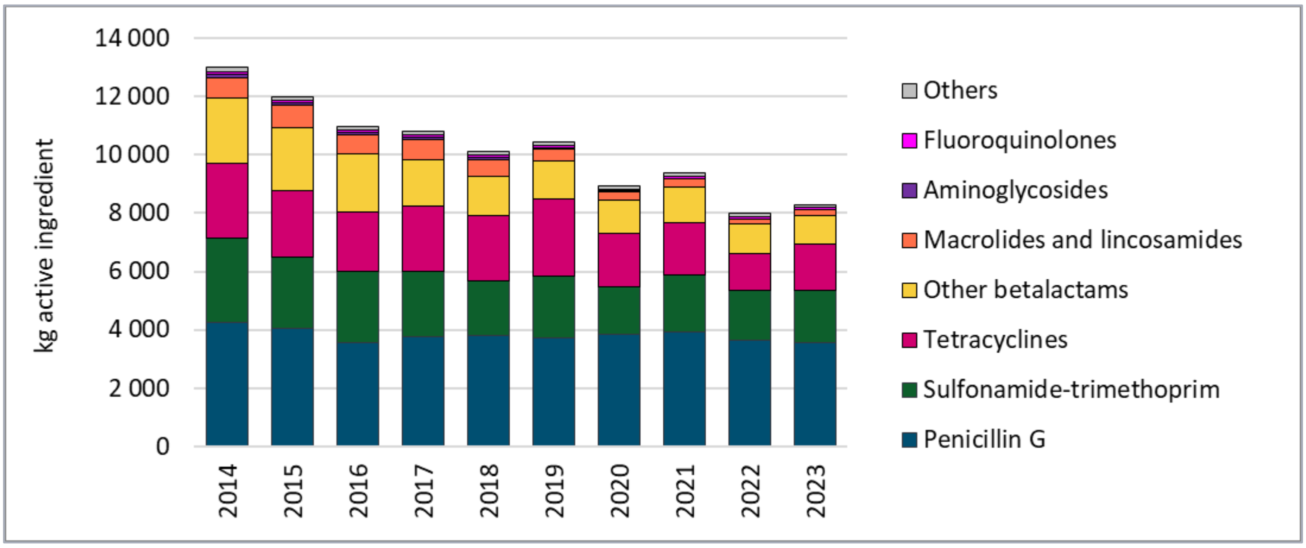

***Figure 1.2**. Overall sales (kg active ingredient) by class in 2014–2023 (tablets included). Other betalactams = aminopenicillins, cephalosporins and cloxacillin. Others = pleuromutilins, amphenicol and imidazole derivatives. For detailed data in tabulated form, see Appendix 2.*

The most-sold antibiotics are penicillin G (43%), sulfonamide-trimethoprim combinations (21%) and tetracyclines (19%) (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 0.7% and 3rd generation cephalosporins 0.002%). WHO considers also macrolides as HPCIA, their sales for use in animals in Finland was also low (1.4% of the overall sales in 2023, Table A6 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 2023 were pharmaceutical forms intended for the treatment of individual animals (injectables, oral pastes and intramammary products). The remaining quarter was for products applicable for group treatment (premixes, oral powders, and oral solutions) (Figure 1.3).

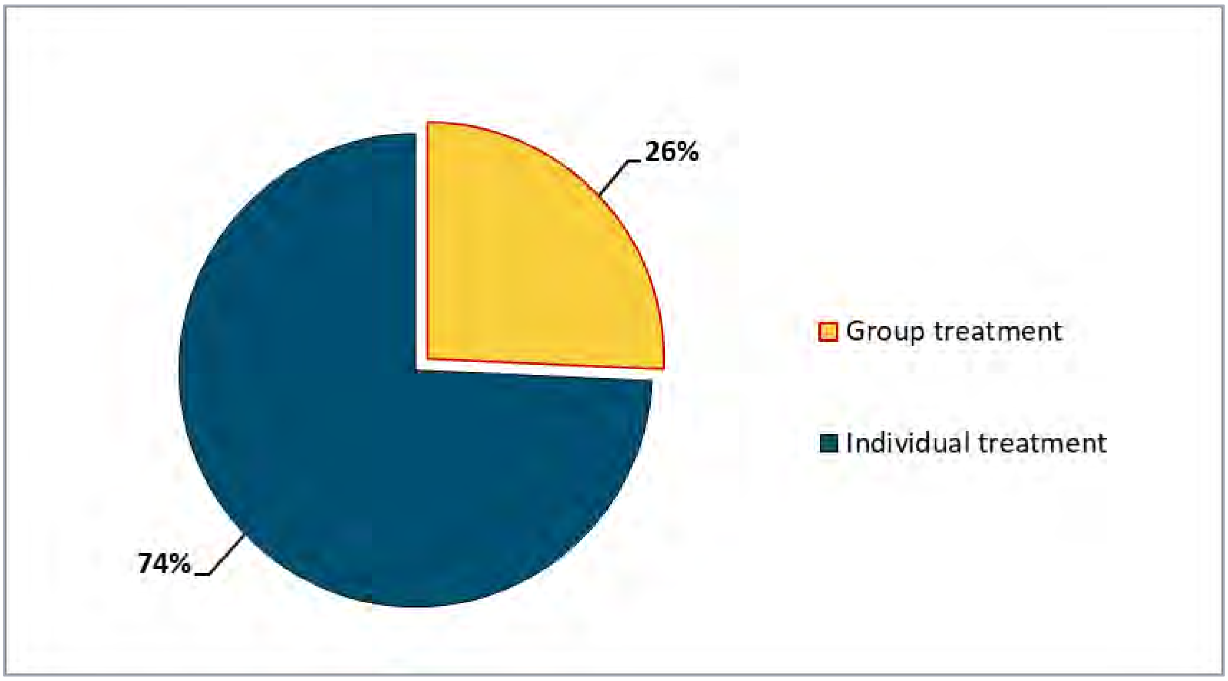

***Figure 1.3**. Sales of veterinary antibiotics for treatment of food-producing animals and fur animals by treatment type (group vs. individual) in 2023 (tablets excluded). Group treatment: premixes, oral solutions, and oral powders. Individual treatment: injectables, intramammaries and oral paste.*

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

Injectables

Half of the antibiotics sold (52%) were products administered as injections to animals (see Appendix 2). The proportion of AMEG D category antimicrobials of the sales of injectables was very high 97% (Fact box 1.). Penicillin continues to be the by far most sold injectable (77%), followed by tetracyclines (12%) and aminopenicillins (5%) (Figure 1.4A).

A decreasing trend in sales of injectable antimicrobials has been noted through 2010’s. From 2022 to 2023 sales of injectables decreased by 5% to 4 325 kg, which is the lowest sales figure ever recorded. Decreased sales were noted especially for penicillin G (-5%), tetracyclines (-6%) and sulfonamide-trimethoprim combination (-12%). For low selling injectables (less than 30 kg/year) fluctuations in annual sales are common. For details see Table A7. in Appendix 2.

Orally administered products (tablets excluded)

Sales of orally administered veterinary antibiotics, excluding veterinary antibiotic tablets, are presented in Figure 1.4B. Two most sold antimicrobials for oral administration were sulfonamide-trimethoprim combination (53%) and tetracyclines (37%), contributing to the high proportion of AMEG D category antimicrobials in orally administered products (93%) (Fact box 1).

Since 2014 a clear downward trend in sales of orally administered products is observed, but annual variation has been significant particularly in recent years (Figure 1.4B and Table A8-A in Appendix 2). After a major fall in sales from 2021 to 2022, a rise by 17% is noted in 2023. This was mainly due to higher sales of tetracyclines (+46%) but also a slight increase in sales of sulfonamide-trimethoprim combination (+6%). The biggest changes were seen in sales of special licence products intended for use in farmed fish.

To note is that some oral powder and oral solution products including e.g. aminopenicillins, cephalosporins and fluoroquinolones, 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 2014–2023.

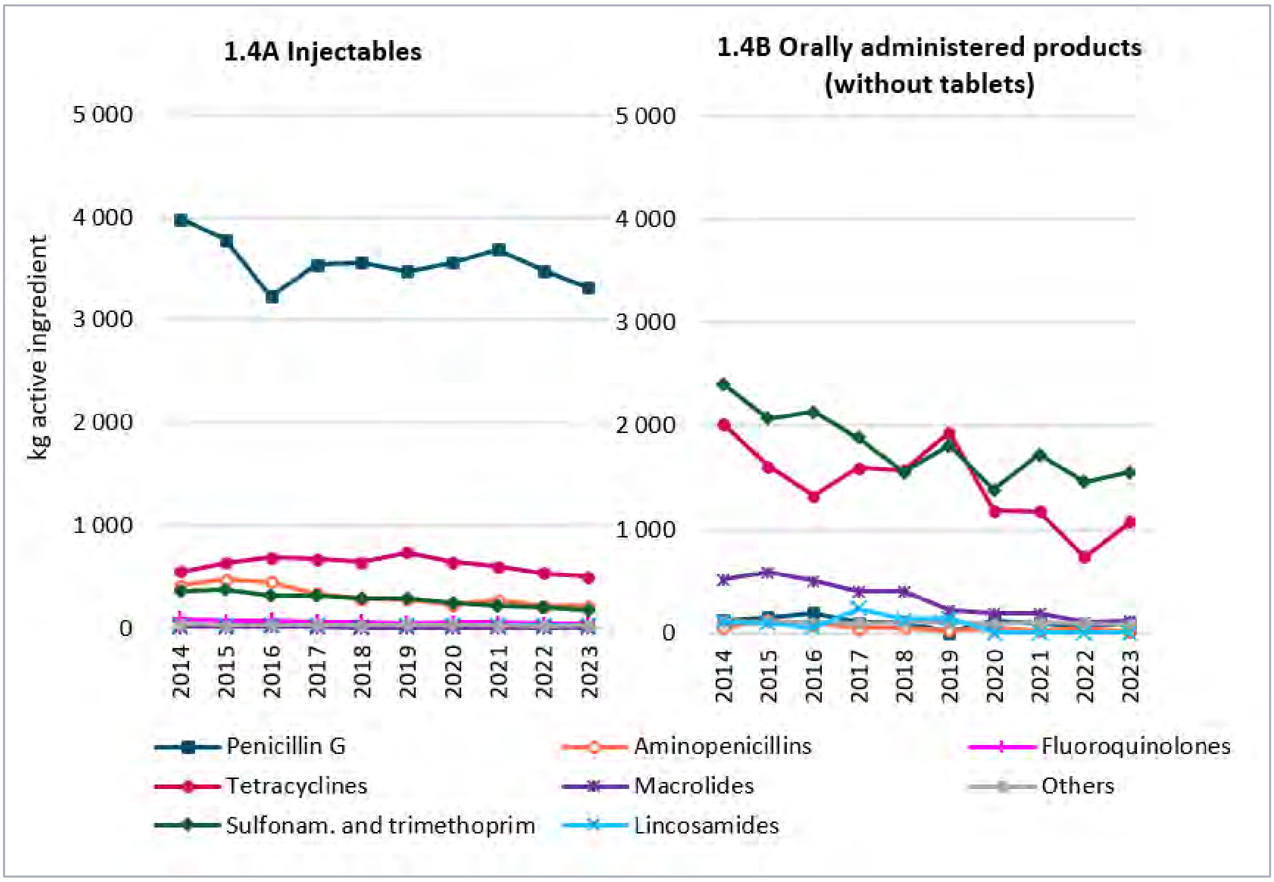

Figure 1.4A and 1.4B. *Trends in sales of injectable (1.4A) and sales of orally administered veterinary antibiotics (1.4B) in 2014–2023 (tablets excluded). Other injectables = amphenicols, aminoglycosides and cephalosporins. Other oral products = amphenicols, 1*st *gen. cephalosporins and pleuromutilins. Detailed data in tabulated form in Appendix 2. Table A7 and A8-A.*

Fact box 1. Sales of veterinary antimicrobials by AMEG category in Finland

Antibiotics have been categorised in the EU into four groups based on their potential consequences to public health due to increased antimicrobial resistance when antibiotics are used in animals. This categorisation has been done by the European Medicine Agency and includes antibiotic classes authorised for human and/or veterinary use in the EU. **The AMEG categorisation is intended as a tool for veterinarians to support prudent use and decision-making on which antibiotic to use** (EMA 2019).

The antibiotics recommended as first line treatment of animals belong to AMEG category D and include e.g. penicillin G, tetracyclines and sulfonamide-trimethoprim combination. If there are no clinically efficient alternatives belonging to category D, then AMEG category C antibiotics can be considered (e.g. macrolides, aminoglycosides, 1st generation cephalosporins and aminopenicillins with beta-lactamase inhibitors). If there are no clinically effective antibiotics in categories C or D, only then can category B antibiotics be considered. All category B antibiotics are critically important in human medicine and their use should be restricted to a minimum.

In 2023 the proportion of AMEG D category antimicrobials of the total veterinary antibiotic sales in Finland was 94%. By administration routes the highest proportion of AMEG D antibiotics was for intramammaries for lactation period (99%), followed by injectables (97%) and orally administered antibiotics (tablets excluded) (93%). For veterinary antimicrobial tablets the proportion of AMEG D category antibiotics was only 9%.

Table 1.2. *The proportion of antibiotic sales by AMEG category for different administration routes in 2023.*

	Total sales 2023	Injectables	Orally administered (excl. tablets)	Tablets	Intrammmaries for lactation period	Intrammmaries for dry cow treatment
AMEG B	1%	1%	0%	1%	0%	0%
AMEG C	5%	2%	7%	90%	1%	24%
AMEG D	94%	97%	93%	9%	99%	76%

Tablets

Veterinary antibiotic tablets are almost solely used for the treatment of companion animals. Their sales have more than halved since 2014 but increased by 10% from 2022 to 2023 (Figure 1.5). This was mainly due to increased sales of amoxicillin and sulfonamide-trimethoprim combination. Sales of 1st generation cephalosporins continued to decrease (-15 % compared to 2022).

Amoxicillins are the most sold veterinary antimicrobial tablets (73%) and their sales consists almost entirely of amoxicillin-clavulanic acid combination (over 99% of amoxicillins in 2023). The second most sold veterinary antimicrobial tablets are 1st generation cephalosporins followed by sulfonamide-trimethoprim combination (Table A8-B. in Annex 2.). Veterinary antibiotics used for treatment of companion animals had in general a broader spectrum than antibiotics used for treatment of food-producing animals in Finland. The proportion of AMEG D category antimicrobials in 2023 was 9% for veterinary antimicrobial tablets compared to 94% in the overall sales in 2023 (Fact box 1.).

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. To which extent this rule is followed, is not known.

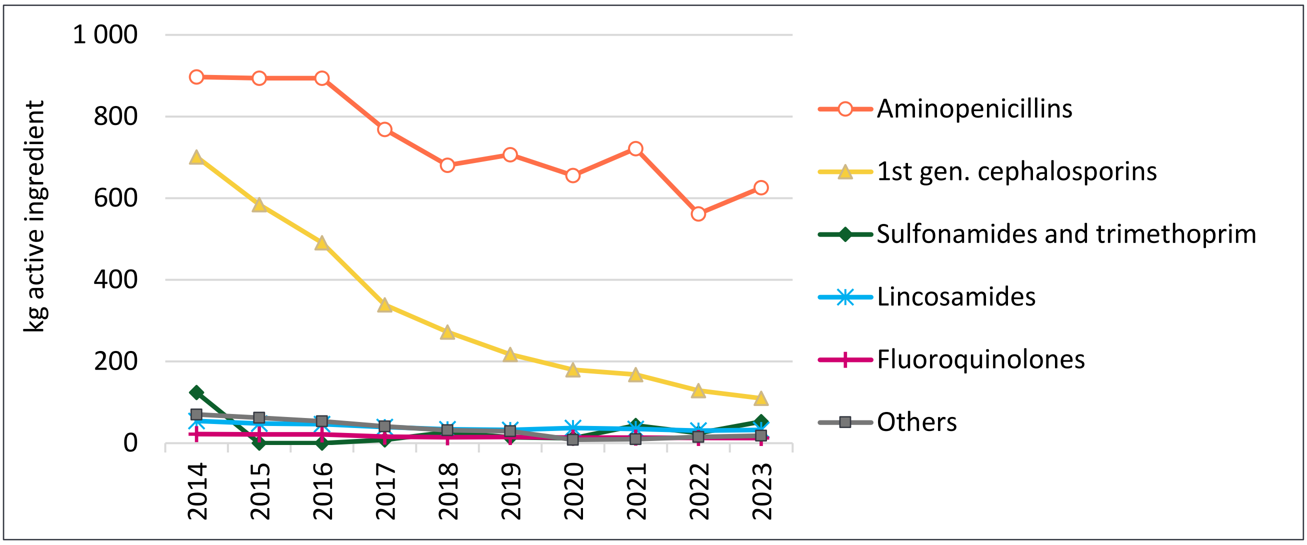

Figure 1.5. *Sales of antibiotic tablets to companion animals (kg active ingredient) by class. Others include tetracyclines, imidazole derivatives and aminoglycosides. Sulfonamide-trimethoprim combination is available through special license.*

Intramammaries

Sales of products for the lactation period have decreased through the 2000’s. Since 2014 sales of intramammary products for the lactation period per cow have almost halved (-53%). In 2014 approximately 1.5 tubes for the lactation period were sold per cow whereas in 2023 the corresponding figure was 0.85. All antimicrobial intramammary products for use during the lactation period in Finland belong to AMEG category D i.e. are of narrow spectrum. Penicillin is the by far most used antimicrobial for the lactation period (85%), followed by cloxacillin (14%). Despite the decreasing sales of intramammary tubes for the lactation period per cow (- 4% in 2022-2023) (Figure 1.7), sales of penicillin for the lactation period in kg turned to a marked + 22% increase in 2023 (Table A9-A. in Appendix 2.). This is due to the fivefold difference in the strength of active ingredient in intramammary products containing penicillin (3 grams/tube vs. 0.6 grams/tube) and changes in sales of these products.

The large-scale shortage concerning dry cow intramammary products continued in 2023. Again special license arrangements were necessary to secure the availability of replacement products. To note is that dry cow products authorised in Finland are more narrow spectrum compared to the special licence products that were available as their replacement. After the all-time low in 2022, sales of dry cow products increased by 6% in 2023 resulting in 0.8 dry cow tubes sold per cow. This corresponds to a 7% increase compared to 2022 (Figure 1.6). Also for dry cow tubes penicillin was the most-sold antibiotic (56%) followed by cloxacillin (20%) and aminoglycosides (22%) (Tables A9-A and A9-B in Appendix 2).

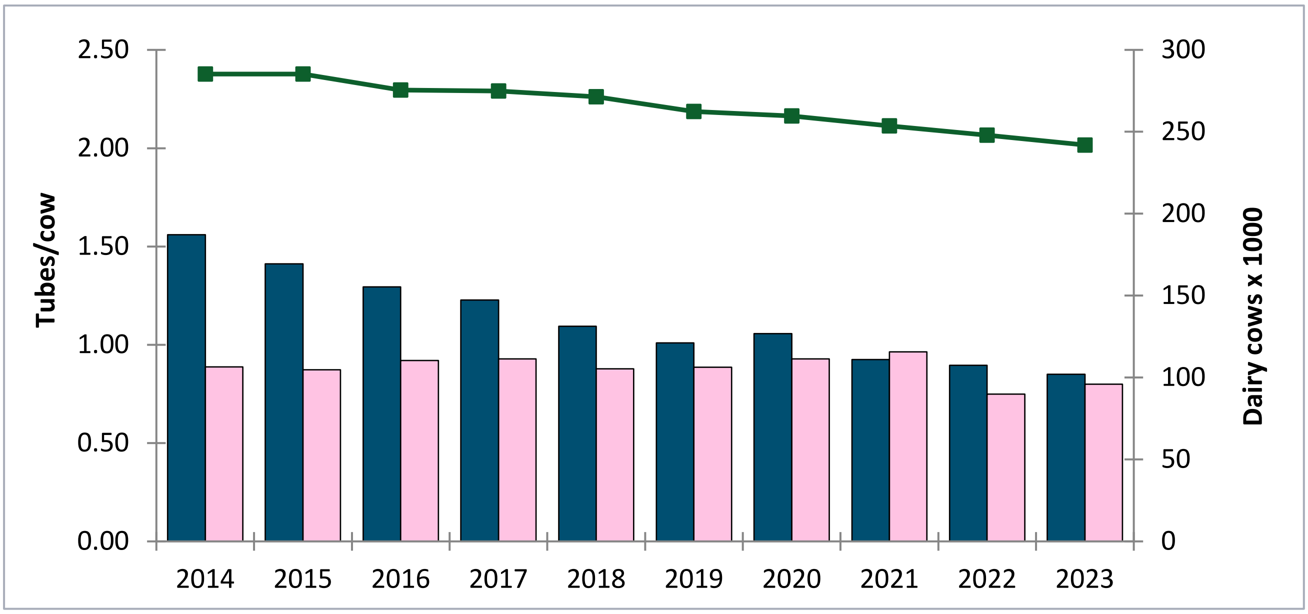

Figure 1.6. *Antibiotics for intramammary use per cow during lactation period (blue column) and during dry cow period (pink column) and the number of dairy cows (green curve).*

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 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.

In 2023 a small increase was noted for overall sales of veterinary antibiotics for food-producing animals (7%; 1.0 mg/PCU). Sales of 3rd generation cephalosporins continued to decrease (-14%) and was the lowest ever recorded (0.003 mg/kg). Sales of fluoroquinolones was stable at 0.10 mg/PCU (1% increase).

Table 1.3. *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 for companion animals.*

Sales (mg/PCU)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Overall sales	21.7	20.0	18.1	18.8	18.1	19.0	16.2	17.1	14.9	15.9
Fluoroquinolones	0.18	0.14	0.15	0.12	0.13	0.10	0.11	0.11	0.10	0.10
3rd generation cephalosporins	0.016	0.014	0.006	0.001	0.001	0.0005	0.0004	0.0004	0.0003	0.0003

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 2023, 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 2022 but was still higher than in 2014–2021 (Table 1.4). In 2023, the use of coccidiostats was 39% higher than in 2014.

Table 1.4. *The use of coccidiostats, antibiotic and other substances in feed in Finland 2014–2023 (kg active substance/year).*

Substance	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Coccidiostats										
Decoquinate	0	0	0.1	0	0	0	0	0	0	0
Diclazuril	0	0	0	0.8	0.5	0.04	0	0	0.15	0.34
Lasalocid sodium	0	0	0	0	1 336	0	0	0	0	0
Madmuramycin ammonium	0	0	0	0	0	0	0	0	0	0
Monensin sodium	6 677	12 640	15 373	14 693	5 097	13 979	14 710	14 767	17 410	15 855
Narasin	9 022	5 478	5 026	4 918	13 152	6 535	6 084	6 428	6 191	5 921
Nicarbazin	0	0	0	0	0	0	0	117	0	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										
Avoparcin	0	0	0	0	0	0	0	0	0	0
Flavomycin	0	0	0	0	0	0	0	0	0	0

Substance	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	**15 699**	**18 117**	**20 399**	**19 613**	**18 585**	**20 514**	**20 795**	**21 312**	**23 601**	**21 777**

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 0.5%. *Salmonella* has been rare in Finnish food-producing animals and domestic foods of animal origin. *Salmonella* isolates from the control programme are tested for antibiotic susceptibility and included in the FINRES-Vet programme.

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 2023, 44 *Salmonella* isolates from food-producing animals were included in the resistance monitoring. Most of the isolates originated from cattle (n=23) and pigs (n=15). Four isolates originated from broilers and two from laying hens. The most common serotypes were *S*. Typhimurium (n=21) and *S.* Enteritidis (n=7). Other serotypes are shown in Appendix 4.

Resistance in *Salmonella* from food-producing animals was very low (Table 2.1). Four *S*. Typhimurium isolates resistant to ampicillin, chloramphenicol, sulfamethoxazole and tetracycline were found from broilers. All other *Salmonella* isolates from food-producing animals in Finland were susceptible to the tested antibiotics.

Salmonella is overall rarely found from Finnish food-producing animals, and also the occurrence of resistance in *Salmonella* isolates has been low. Multi-drug resistance has been found yearly from 2018 (Figure 2.1).

Table 2.1. *Distribution of MICs for Salmonella enterica from food-producing animals in 2023 (n=44).*

			Distribution (%) of MICs (mg/L)																
Substance	**%R**	**95% C.I.**	**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	0.0–8.0									100								
Ampicillin	9.1	3.6–21.2							18.2	68.2	4.5				9.1				
Azithromycin	0	0.0–8.0								9.1	45.5	45.5							
Cefotaxime[1]	0	0.0–8.0					100												
Ceftazidime	0	0.0–8.0					47.7	50.0	2.3										
Chloramphenicol	9.1	3.6–21.2										88.6	2.3			9.1			
Ciprofloxacin	0	0.0–8.0	38.6	59.1	2.3														
Colistin[2]									81.8	18.2									
Gentamicin	0	0.0–8.0						88.6	11.4										
Meropenem[3]	0	0.0–8.0		50.0	50.0														
Nalidixic acid	0	0.0–8.0									90.9	9.1							
Sulfamethoxazole[4]	9.1	3.6–21.2										4.5	18.2	54.5	6.8	6.8			9.1
Tetracycline	9.1	3.6–21.2								84.1	6.8			4.5	4.5				
Tigecycline[5]							90.9	9.1											
Trimethoprim[1]	0	0.0–8.0					59.1	40.9											

Bold vertical lines indicate current (28.5.2024) 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 mg/L), 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 mg/L is used (dashed vertical line) for resistance monitoring purposes. [4]For sulfamethoxazole, no EUCAST ECOFF is available, therefore, a cut-off value of >256 mg/L is used (dashed vertical line) for resistance monitoring purposes. [5]For tigecycline, no EUCAST ECOFF is available.

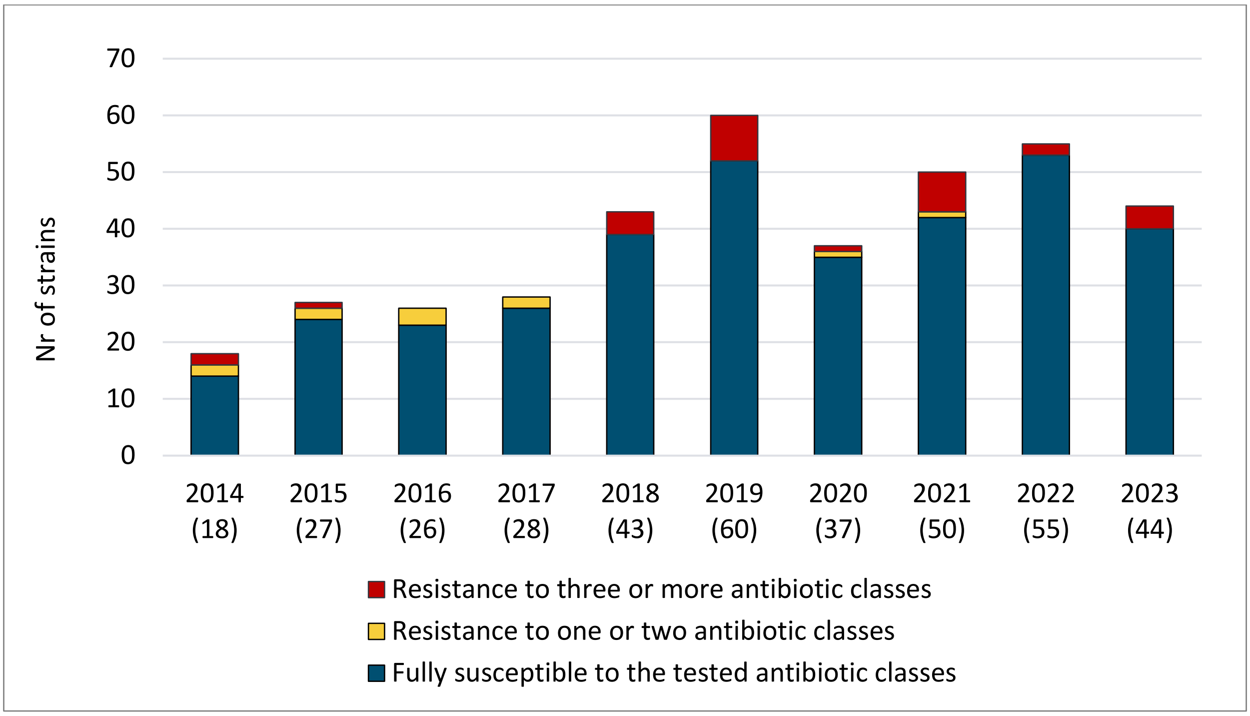

Figure 2.1*. The number of sensitive and resistant Salmonella isolates from food-producing animals in Finland in 2014–2023. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides, beta-lactams, phenicols, quinolones, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

2.2 *Campylobacter* from food-producing animals

In 2023, *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 2023, two *C. coli* isolates from broilers were detected in the national control programme.

2.2.1 *Campylobacter spp.* from broilers

Within the national *Campylobacter* control programme of broilers in 2023, 55 *C. jejuni* and two *C. coli* isolates were tested for susceptibility. Of these, three *C. jejuni*-isolates (5.5%) were resistant to ciprofloxacin and tetracycline. Resistance against the other studied antibiotics was not detected (Table 2.2).

Table 2.2. *Distribution of MICs for Campylobacter jejuni from broilers in 2023 (n=55).*

			Distribution (%) of MICs (mg/L)													
Substance	**%R**	**95% C.I.**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**>512**
Chloramphenicol	0.0	0.0–6.5					96.4	3.6								
Ciprofloxacin	5.5	1.9–14.9	69.1	25.5					3.6		1.8					
Ertapenem[1]	0.0	0.0–6.5	96.4	1.8	1.8											
Erythromycin	0.0	0.0–6.5				100.0										
Gentamicin	0.0	0.0–6.5		3.6	65.5	30.9										
Tetracycline	5.5	1.9–14.9			92.7	1.8					1.8		3.6			

Bold vertical lines indicate current (28.5.2024) EUCAST epidemiological cut-off (ECOFF) values for resistance except for ertapenem[1], for which no EUCAST ECOFF is available, therefore, a cut-off value of >0,5 mg/L is used (dashed vertical line) for resistance monitoring purposes. 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.

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 at a low level. 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 2023, the proportions of quinolone and tetracycline resistant isolates have remained again at a low level (Figure 2.2). The proportions of resistant isolates 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 2.3). Multidrug resistance has not been detected.

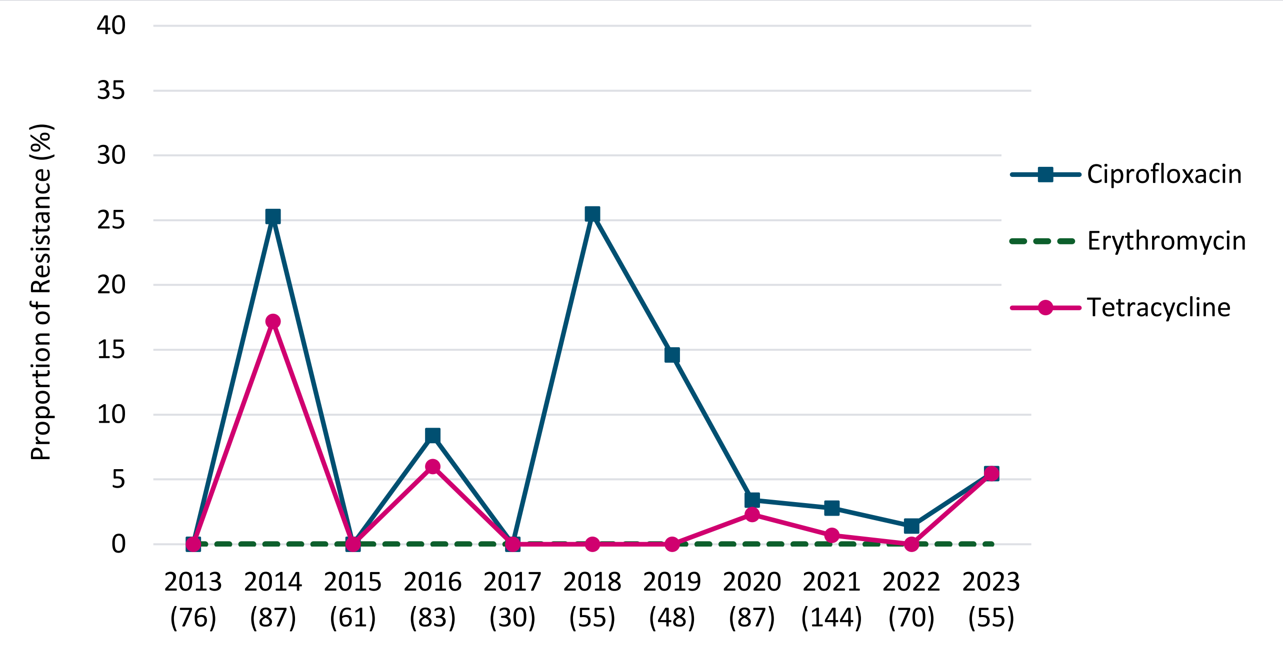

Figure 2.2. *The proportions of resistant Campylobacter jejuni isolates against selected antibiotics from broilers at slaughter in Finland between the years 2013 and 2023. The number of isolates tested each year are in brackets.*

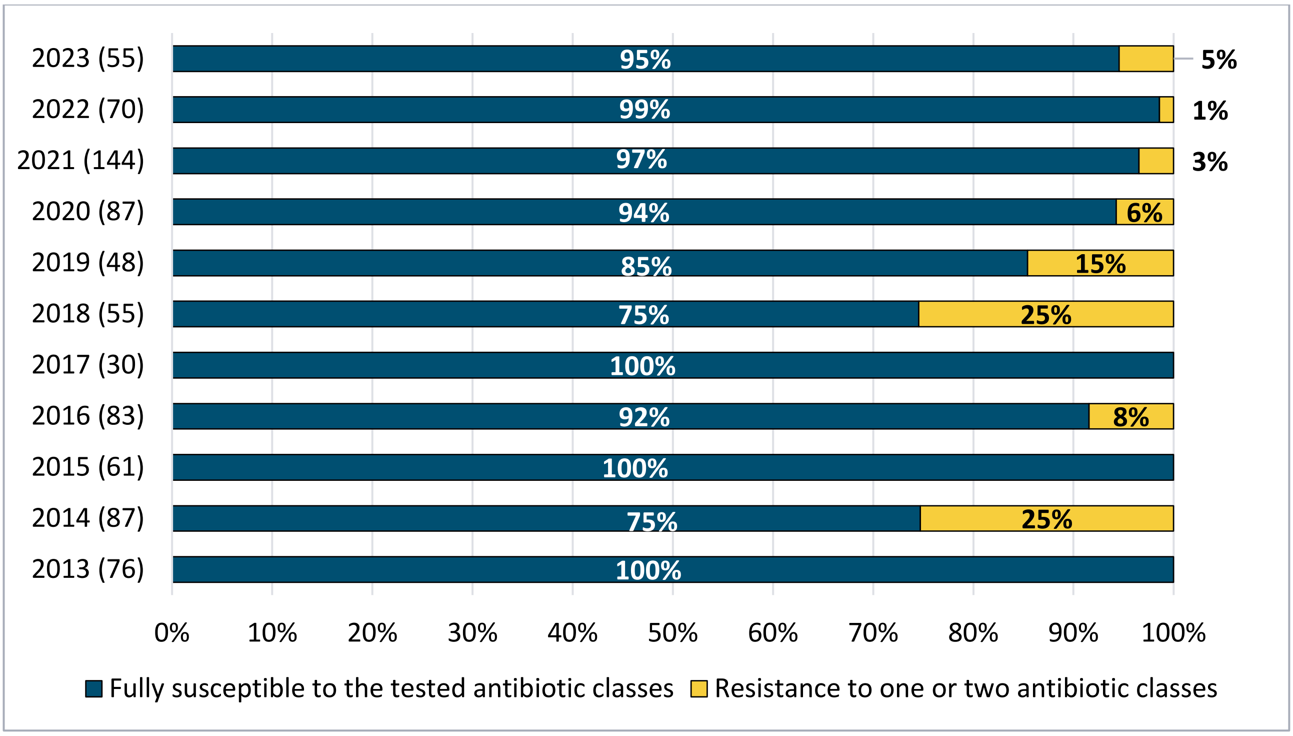

Figure 2.3. *Antibiotic susceptibility of Campylobacter jejuni isolated from broilers at slaughter in Finland between the years 2013 and 2023. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides (gentamicin), fluoroquinolones (ciprofloxacin), macrolides (erythromycin), and tetracyclines.*

2.2.2 *Campylobacter spp.* from pigs

Campylobacter coli bacteria have been isolated in the FINRES-Vet monitoring programme from pigs every third or fourth year since 2004. In 2021 it became mandatory to report susceptibility data of *C. coli* from pigs every other year in the EU (Commission implementing decision (EU) 2020/1729). In 2023, 175 *C. coli* isolates from swine caecal samples, collected at slaughter, were studied for antibiotic resistance. Of these, 48 (27.4%) were resistant to ciprofloxacin and one (0.6%) to erythromycin (Table 2.3). Resistance against the other studied antibiotics was not detected. Additionally, five *C. jejuni* isolates were detected from pigs and tested for susceptibility. Three out of five (60%) *C. jejuni* were resistant to ciprofloxacin.

The proportion of fluoroquinolone resistant isolates has been moderate to high between 2013 and 2023 while the proportions of resistant isolates for other antibiotic classes has remained at a low level or nonexistent (Table 2.3, Figure 2.4). During the same time, the proportions of fully susceptible isolates have varied between 66% and 82% being at their lowest in the year 2021 (Figure 2.5). This is almost solely due to fluoroquinolone resistance. In 2023, the proportion of resistant isolates decreased approximately 6 percentage points as compared to the previous study year of 2021.

Table 2.3. *Distribution of MICs for Campylobacter coli from pigs in 2023 (n=175).*

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	0.0–2.1					34.3	58.9	6.9							
Ciprofloxacin	27.4	21.4–34.5	50.9	21.7				1.1	14.9	9.7	1.7					
Ertapenem[1]	0.0	0.0–2.1	83.4	16.6												
Erythromycin	0.6	0.1–3.2				78.3	14.9	6.3								0.6
Gentamicin	0.0	0.0–2.1		0.6	10.3	85.7	3.4									
Tetracycline	0.0	0.0–2.1			89.7	8.6	1.7									

Bold vertical lines indicate current (28.5.2024) EUCAST epidemiological cut-off (ECOFF) values for resistance except for ertapenem[1], for which no EUCAST ECOFF is available, therefore, a cut-off value of >0,5 mg/L is used (dashed vertical line) for resistance monitoring purposes. 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.

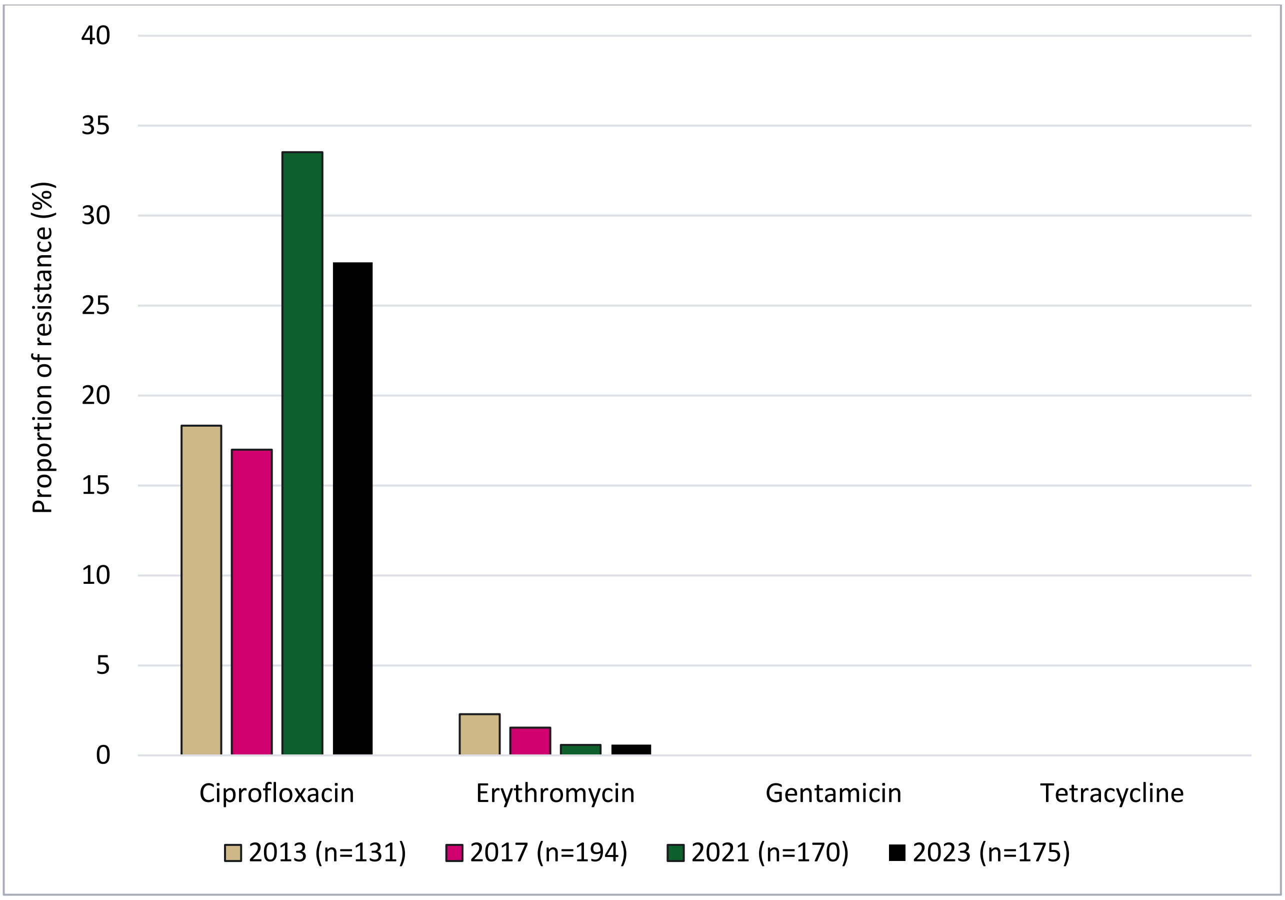

Figure 2.4. *The proportions of resistant Campylobacter coli isolates from pigs at slaughter in Finland between the years 2013 and 2023. The number of isolates tested each year are in brackets.*

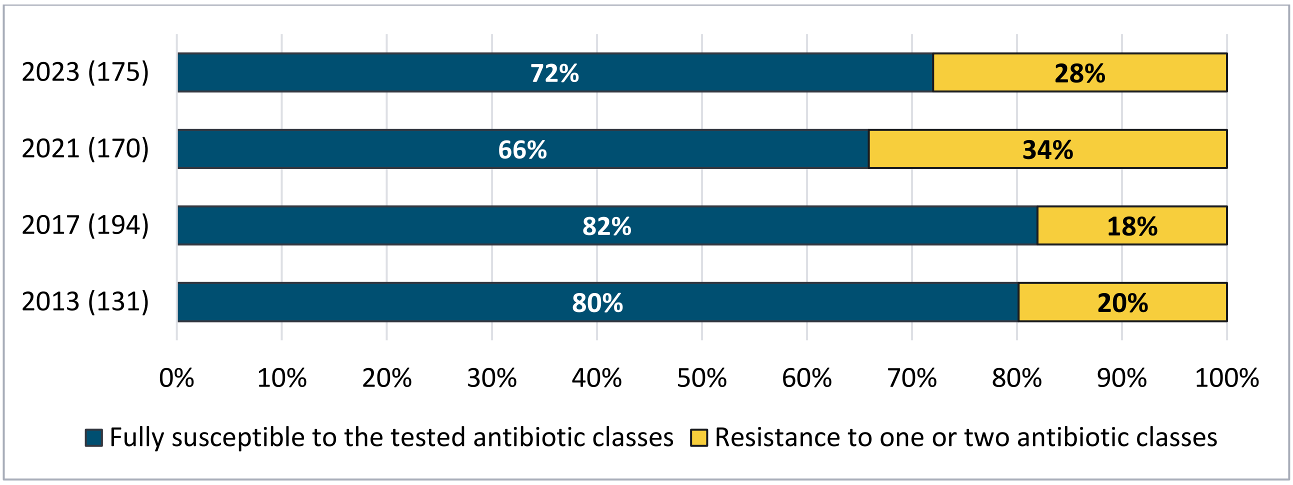

Figure 2.5. *Antibiotic susceptibility of Campylobacter coli isolated from pigs at slaughter in Finland between the years 2013 and 2023. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides (gentamicin), fluoroquinolones (ciprofloxacin), 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 pigs and meat from pigs and bovines in 2023.

In 2021, it became mandatory in the 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. In 2023, imported fresh meat from pigs and bovines originating from third countries was not included in the monitoring. Only one consignment of fresh meat from bovines was imported but due to difficulties in sampling at the border control post, samples were not taken. No consignments of meat from pigs were imported to Finland in 2023.

Additionally, liners from the transport boxes of imported broiler 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 pigs and meat from pigs and bovines

In 2023, extended-spectrum beta-lactamase (including AmpC beta-lactamase) producing E. coli were screened with selective isolation method from pig caecal samples (n=300) collected at slaughterhouses as well as from fresh pork (n=302) and beef (n=299) samples collected at retail. The majority of the pork (n=299, 99%) and beef samples (n=273, 91%) were of domestic origin.

In 2023, the prevalence of ESBL- or AmpC-producing E. coli in pigs was 6.3%, AmpC being the predominant phenotype (Table 3.1). Neither ESBL- nor arbapenemase-producing E. coli were detected. Compared to the previous monitoring year 2021, the prevalence of ESBL/AmpC-producing E. coli in pigs stayed on the same level (Table 3.1, Figure 3.1). Molecular analysis of the isolates (n=19) revealed beta-lactamase genes $bla_{DHA\text{-}1}$ (n=1) and $bla_{CMY\text{-}2}$ (n=1). In addition, AmpC promoter region mutations C-42T (n=16) and T-32A (n=1) were detected. AmpC phenotypes corresponded to the molecular findings. In addition, four of these isolates were found carrying other resistance genes including *aph(6)-Id* (n=3) and *aph(3'')-Ib* (n=1) conferring resistance to streptomycin, macrolide resistance gene *mph(A)* (n=1)), ciprofloxacin resistance gene *qnrB4* (n=1) sulfamethoxazole resistance genes *sul1* (n=1) and *sul2* (n=3), trimethoprim resistance genes *dfrA17* (n=1) and *sfrA14* (n=2) and tetracycline resistance gene *tet(A)* (n=1).

Most of the meat samples (pork, beef) collected from retail shops have been of domestic origin. In 2023, no ESBL-, AmpC- or carbapenemase-producing *E. coli* were isolated from pork. One isolate was detected in beef of non-domestic origin resulting in a prevalence of 0.3%. According to molecular analysis, the isolate harboured beta-lactamase gene $bla_{CTX\text{-}M\text{-}15}$ corresponding to the ESBL phenotype of the isolate. In addition, ciprofloxacin resistance conferring gene *qnrS1* was detected in the molecular analysis of this isolate.

ESBL/AmpC-producing *E. coli* have been very rare in pork and beef in all the studied years 2015, 2017, 2019, 2021 and 2023 (Figure 3.1, Figure 3.2). ESBL/AmpC-producing *E. coli* in cattle were last monitored in 2020 when these bacteria were found in 3.1% of the samples (Figure 14). Carbapenemase-producing *E. coli* was not detected in any of the meat samples.

Table 3.1. *Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing E. coli in food-producing animals and meat in 2015, 2016, 2017, 2019, 2020, 2021 and 2023.*

Year	Sampling stage	Nr of samples	Nr (%) of ESBL[1]	Nr (%) of AmpC[1]	Nr of CP-EC[2]	% ESBL/AmpC
Pigs						
2023	at slaughter	300	0 (0%)	19 (6.3%)	0	6.3%
2021	at slaughter	307	2 (0.7%)	18 (5.9%)	0	6.5%
2019	at slaughter	288	1 (0.3%)	6 (2.1%)	0	2.4%
2017	at slaughter	299	1 (0.3%)	7 (2.3%)	0	2.7%
2015	at slaughter	306	1 (0.3%)	8 (2.6%)	0	2.9%
Pork						
2023	at retail	302	0 (0%)	0 (0%)	0	0%
2021	at retail	313	0 (0%)	0 (0%)	0	0%
2019	at retail	306	0 (0%)	0 (0%)	0	0%
2017	at retail	301	0 (0%)	0 (0%)	0	0%
2015	at retail	303	0 (0%)	1 (0.3%)	0	0.3%
Beef						
2023	at retail	299	1 (0.3%)[4]	0 (0%)	0	0.3%
2021	at BCP[5]	1	0 (0%)	0 (0%)	0	0%
2021	at retail	313	0 (0%)	0 (0%)	0	0%
2019	at retail	297	2 (0.7%)[4]	0 (0%)	0	0.7%
2017	at retail	302	0 (0%)	0 (0%)	0	0%
2015	at retail	300	0 (0%)	0 (0%)	0	0%

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

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

[3] CP-EC were screened from 204 samples.

[4] beef of non-domestic origin

[5] border-control post

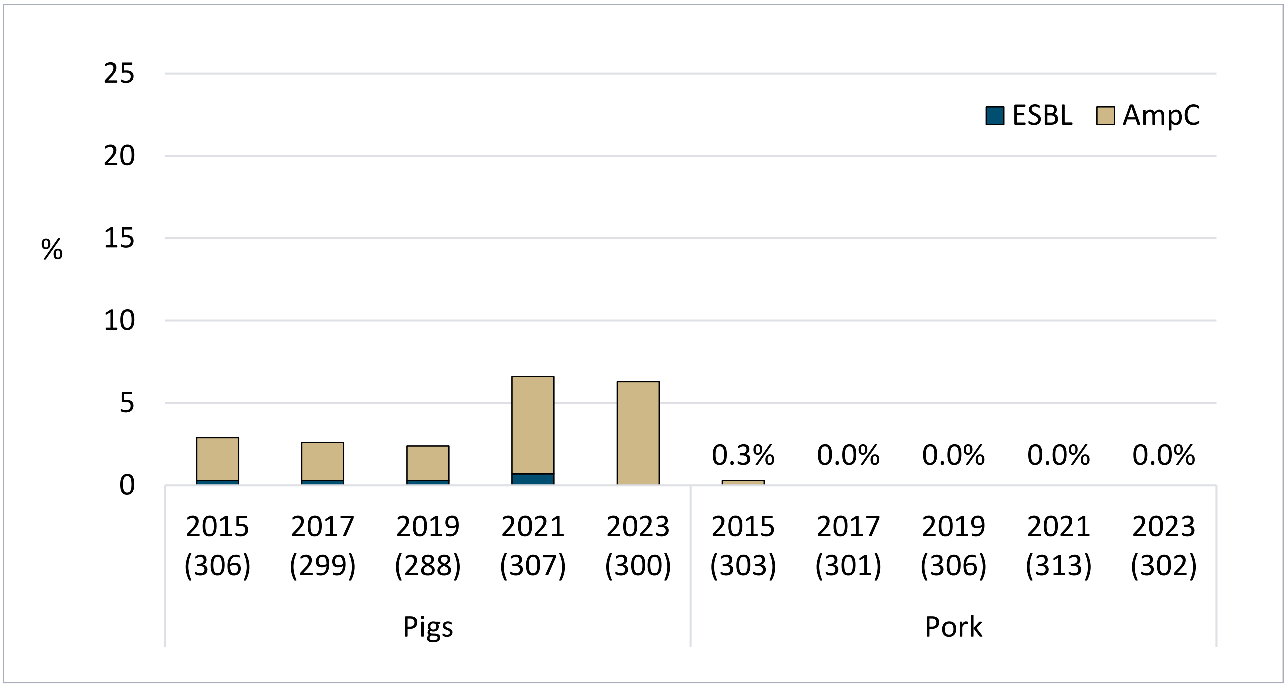

***Figure 3.1**. Prevalence (%) of ESBL- and AmpC-producing E. coli in pigs and pork in 2015, 2017, 2019, 2021 and 2023. The number of samples tested each year is in brackets.*

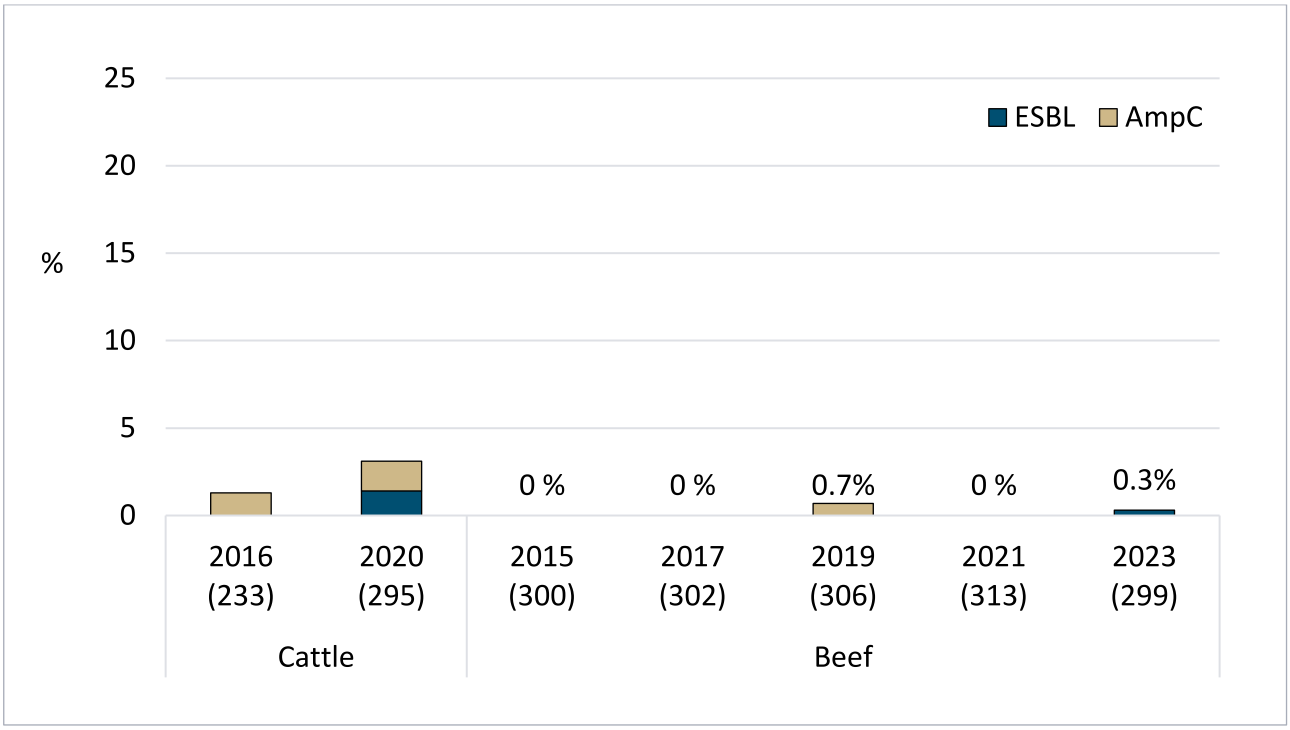

***Figure 3.2.** Proportion of ESBL- and AmpC-producing E. coli in cattle in 2016 and 2010, and in beef in 2015, 2017, 2019, 2021 and 2023. The number of samples tested each year is in brackets.*

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

In 2023, liners of transport boxes of imported poultry flocks intended for broiler meat, turkey meat and chicken egg production chains were screened for ESBL/AmpC- and carbapenemase-producing *E. coli* (Table 3.2). 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 2023. Imported poultry flocks have been part of the resistance monitoring since 2015. The majority of the ESBL/AmpC *E. coli* positive flocks were detected between 2015 and 2017. Thereafter, positive findings have been rare. Carbapenemase-producing *E. coli* have not been detected at all.

Table 3.2. *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 2015–2023.*

Imported poultry flocks	2015	2016	2017	2018	2019	2020	2021	2022	2023
For broiler meat production									
Nr of sampled flocks	54	62	37	42	38	34	35	29	28
Nr of ESBL positive flocks	1	0	0	0	0	0	0	0	0
Nr of AmpC positive flocks	9	24	8	0	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%)	0 (0%)
For turkey meat production									
Nr of sampled flocks	6	5	4	5	5	4	6	4	5
Nr of ESBL positive flocks	0	0	0	0	0	0	0	0	0
Nr of AmpC positive flocks	0	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%)	0 (0%)
For egg production									
Nr of sampled flocks	4	3	4	5	3	5	3	4	1
Nr of ESBL positive flocks	1	0	0	0	0	0	0	0	0
Nr of AmpC positive flocks	2	0	3	0	0	1	0	0	0
Nr (%) of ESBL/AmpC positive flocks	3 (75%)	0 (0%)	3 (75%)	0 (0%)	0 (0%)	0 (20%)	0 (0%)	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 2023, 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 fecal or post-mortem samples submitted to the Finnish Food Authority. All isolates were confirmed by PCR to be enterotoxigenic. Altogether, 20 *E. coli* isolates from 11 different farms were included. The number of isolates (20) and farms (11) sending samples in 2023 was very small compared to 2022. Therefore, chance likely has a large impact on the results, and no conclusions can be drawn from them as to whether there have been real changes in the resistance situation or not. Furthermore, at least some of these 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 4.1. As before, resistance was commonly detected against ampicillin, fluoroquinolones, tetracycline, streptomycin, as well as sulfamethoxazole, trimethoprim, and their combination (Figure 4.1). The resistance situation on pig enteritis *E. coli* remains worrying.

In 2023, resistance to chloramphenicol was low and no resistance to florfenicol was detected. Also, no resistance against gentamicin has been detected between 2016 and 2023. Resistance against 3rd generation cephalosporins (according to the epidemiological cut-off values) was detected in nine isolates from five farms, from which all were phenotypically AmpC. No ESBL-producers were found. The proportion of multidrug resistance varies annually (Figure 4.2) and in 2023 no isolates were susceptible to all tested antimicrobial classes. This is presumably because of the small number of isolates tested.

In summary, resistance was commonly detected against all antibiotic classes that can be used to treat *E. coli* infections in pigs (sulfonamide-trimethoprim, tetracycline and aminopenicillins). 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.

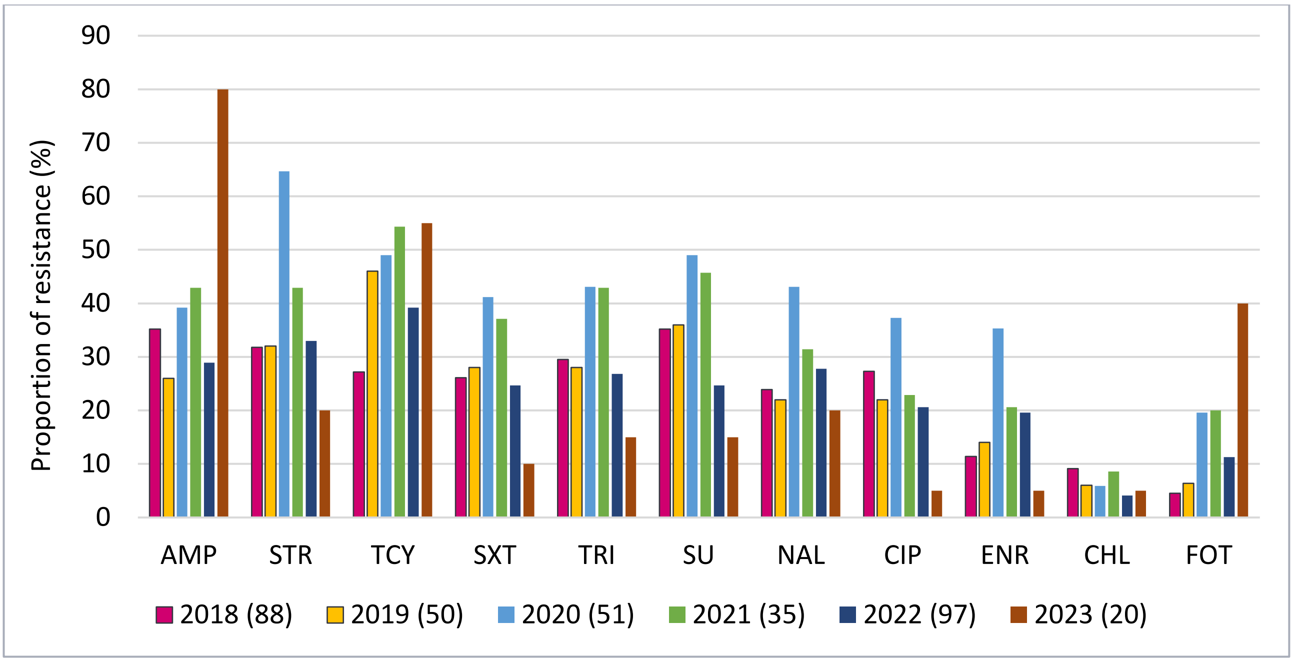

***Figure 4.1**. Resistance to tested antibiotics in 2018–2023, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

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

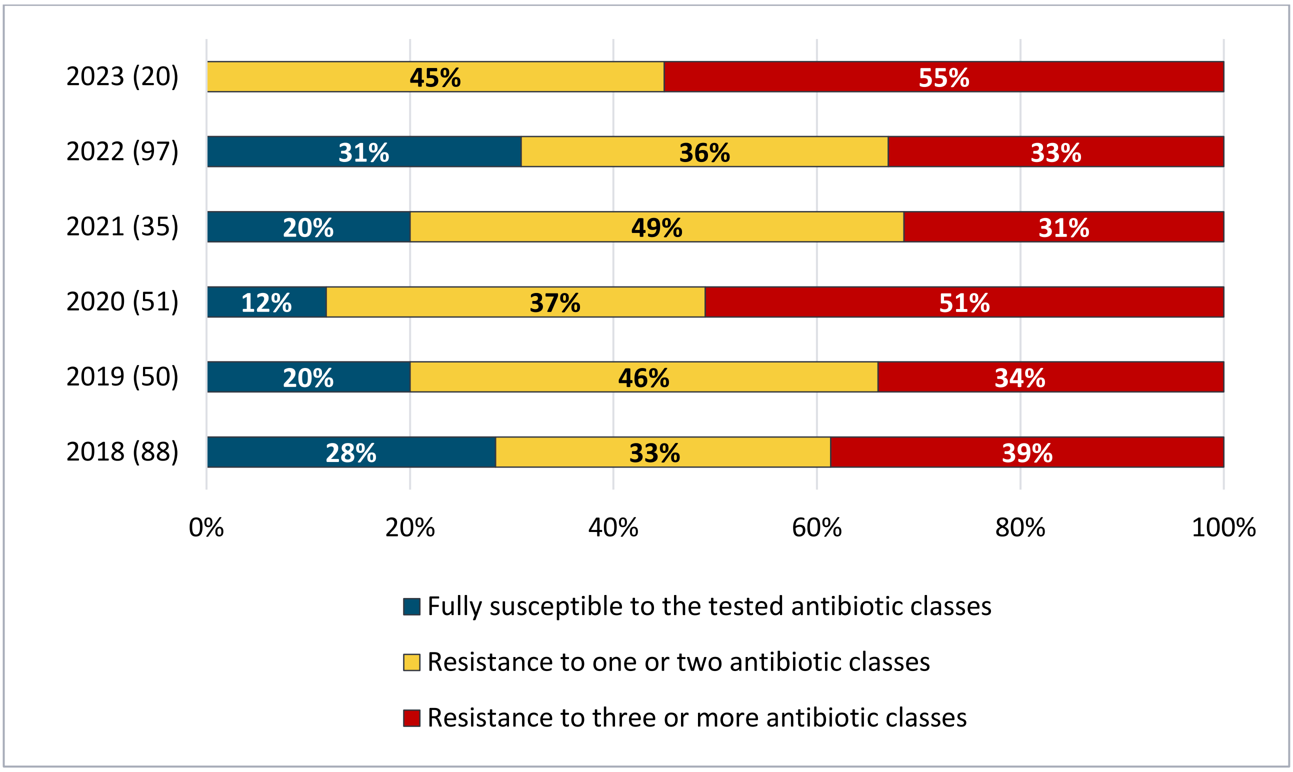

***Figure 4.2**. The proportions of multidrug resistant E. coli isolates from porcine enteritis in 2018–2023, epidemiological cut-off values used. The number of isolates tested each year are in brackets. Antibiotic classes included in the analysis: aminoglycosides, aminopenicillins, amphenicols, fluoroquinolones, 3rd generation cephalosporins, polymyxins, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

Table 4.1. *Distribution of MICs for Escherichia coli from porcine enteritis in 2023 (n=20). Resistance percentage is the proportion of resistance calculated with epidemiological cut-off values.*

			Distribution (%) of MICs (mg/L)																	
Substance	**%R**	**95% C.I.**	**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	80.0	58.4–91.9								10.0	5.0	5.0	10.0	15.0	55.0					
Cefotaxime	40.0	21.9–61.3			35.0	10.0	15.0	15.0	15.0	10.0										
Ceftazidime	20.0	8.1–41.6					45.0	20.0	15.0	5.0	15.0									
Chloramphenicol	5.0	0.9–23.6									45.0	50.0		5.0						
Ciprofloxacin	5.0	0.9–23.6	65,0	15.0	15.0		5.0													
Colistin	0.0	0.0.-16.1							95.0	5.0										
Enrofloxacin	5.0	0.9–23.6			80.0	15.0		5.0												
Florfenicol	0.0	0.0.-16.1									45.0	55.0								
Gentamicin	0.0	0.0.-16.1						85.0	15.0											
Nalidixic acid	20.0	8.1–41.6									80.0			10.0	5.0	5.0				
Streptomycin	20.0	8.1–41.6									40.0	40.0		10.0	10.0					
Sulfamethoxazole[1]	15.0	5.2–36.0										65.0	20.0							15.0
Tetracycline	55.0	34.2–74.2							5.0	30.0	10.0				5.0	40.0	10.0			
Trimethoprim	15.0	5.2–36.0					40.0	5.0	15.0	25.0				15.0						
Trim/sulfa[2]	10.0	2.8–30.1						85.0	5.0			10.0								

Bold vertical lines indicate current (28.5.2024) 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 2023, 26 isolates from 22 farms were tested for antibiotic susceptibility. All obtained isolates were included. Clinical breakpoints (CLSI, 2020) were used to evaluate decreased susceptibility (Table 4.2). In 2023, isolates were slightly more resistant to oxytetracycline than previously. One isolate was resistant and has been the only resistant isolate in the last ten years. Otherwise, no significant changes in the MICs for the tested substances can be seen between 2016 and 2023. Each year the number of tested isolates has been rather small.

Table 4.2. *Distribution of MICs for Actinobacillus pleuropneumoniae from pigs in 2022 (n=26).*

			Distribution (%) of MICs (mg/L)										
Substance	**%R**	**95% C.I.**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Florfenicol	0	0.0-12.9		69.2	30.8								
Ceftiofur	0	0.0-12.9		100									
Penicillin[1]	3.8	0.7-18.9	11,5	65.4	19.2					3.8			
Oxytetracycline	3.8	0.7-18.9			38.5	57.7	3.8						
Tiamulin	0	0.0-12.9						3.8	26.9	69.2			
Tulathromycin	0	0.0-12.9							15.4	46.2	38.5		

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 2023. With these breakpoints, 0% of the isolates were resistant against tiamulin (compared to 16% in 2022), 13% (16% in 2022) against tylosin, 20% (24% in 2022) against lincomycin and 13% (12% in 2022) against tylvalosin (Table 4.3). Resistance in *B. pilosicoli* has mostly been at moderate level from 2015 to 2023 but the number of isolates tested each year has been small. In 2023, only 15 isolates were tested.

Table 4.3. *Distribution of MICs for Brachyspira pilosicoli from pigs in 2023 (n=15).*

	Distribution (%) of MICs (mg/L)													
Substance	**0.03**	**0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**>128**
Doxycycline			86.7	6.7			6.7							
Lincomycin					80.0			6.7		13.3				
Tiamulin		86.7	13.3											
Tylosin							40.0	26.7	20.0					13.3
Tylvalosin					40.0	26.7	20.0			6.7		6.7		
Valnemulin	86.7	13.3												

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 (n=11), obtained from 10 farms, were fully susceptible in 2023. 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* has not been isolated from this farm since 2021.

In 2023, *Pasteurella multocida* isolates were obtained from 111 farms and on 99/111 (89%) of these farms, isolates were fully susceptible (Table 4.4). The majority (91%) of *P. multocida* isolates investigated were fully susceptible, with 9 isolates being resistant to oxytetracycline (originating from 8 farms), one isolate to penicillin and one isolate to penicillin and oxytetracycline. Since 2018, resistance has been low overall among *P. multocida* from bovine respiratory diseases (Figure 4.3). 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 2023 are shown in Table 4.5.

Table 4.4. *Distribution of MICs for Pasteurella multocida from bovine respiratory disease in 2023 (n=152).*

			Distribution (%) of MICs (mg/L)										
Substance	**%R**	**95% C.I.**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Ceftiofur	0.0	0.0–2.5											
Enrofloxacin	0.0	0.0–2.5	99.3	0.7									
Florfenicol	0.0	0.0–2.5		45.4	52.6	2.0							
Oxytetracyclin	6.6	3.6–11.7			75.5	0.5	15.9	1.3		6.6			
Penicillin	1.3	0.4–4.7	90.8	7.9		0.7				0.7			
Tulathromycin	0.0	0.0–2.5				50.0	40.8	8.6		0.7			

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

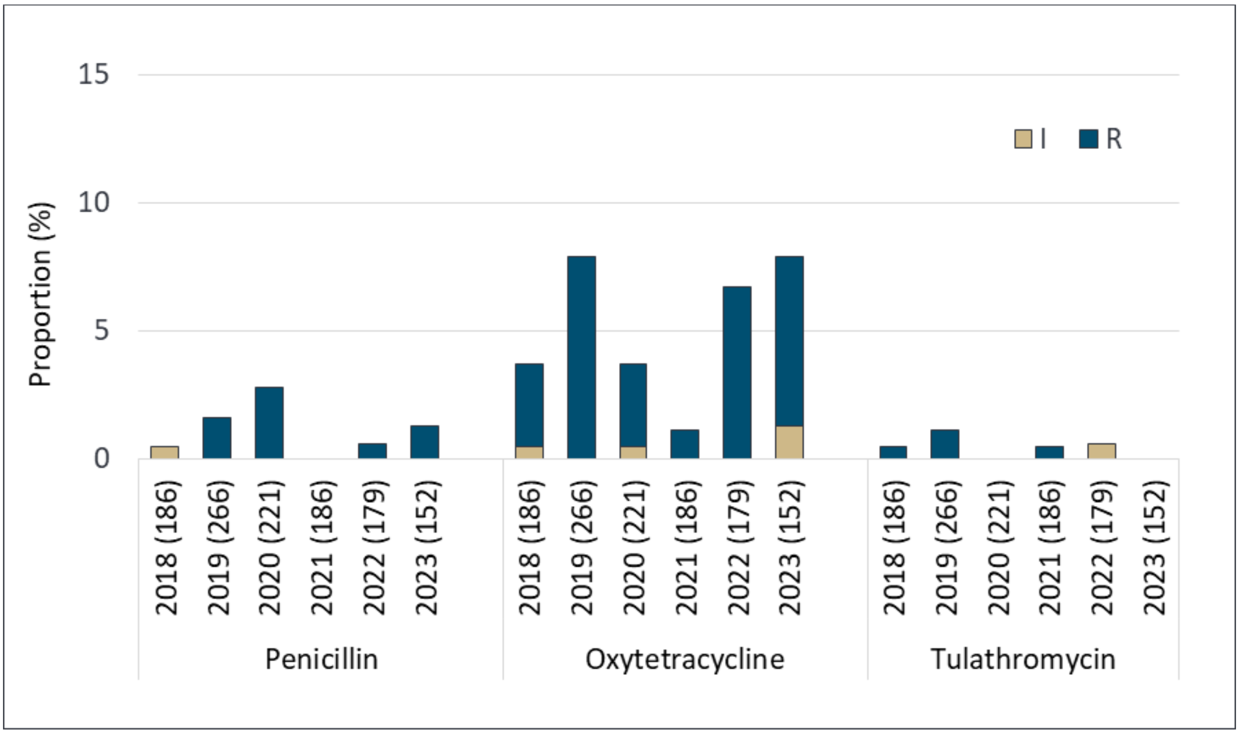

Figure 4.3. *Proportion (%) of Pasteurella multocida from bovine respiratory disease not susceptible to penicillin, oxytetracycline and tulathromycin in 2018–2023. The number of isolates tested each year are in brackets.*

In 2023, a total of 41 *Mannheimia haemolytica* isolates were obtained from 36 farms and isolates were fully susceptible on 64% of these farms. This is lower than in the previous year (78%), when the isolates originated from 46 farms. None of the isolates were resistant to more than one antibiotic. Two oxytetracycline resistant and four penicillin resistant isolates (all from separate farms) were isolated in 2023. Altogether, isolates from eight 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 (Figure 4.4.). The MIC distributions of different antibiotics for *M. haemolytica* isolated in 2023 are shown in Table 4.5.

Table 4.5. *Distribution of MICs for Mannheimia haemolytica from bovine respiratory disease in 2023 (n=41).*

			Distribution (%) of MICs (mg/L)										
Substance	**%R**	**95% C.I.**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**>64**
Ceftiofur	0.0	0.0–8.6		100									
Enrofloxacin	0.0	0.0–8.6	100										
Florfenicol	0.0	0.0–8.6			9.8	90.2							
Oxytetracyclin	4.9	1.3–16.1			34.1	58.5	2.4			4.9			
Penicillin	9.8	3.9–22.5	26.8	41.5	22.0	7.3				2.4			
Tulathromycin	0.0	0.0–8.6				2.4	51.2	46.3					

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

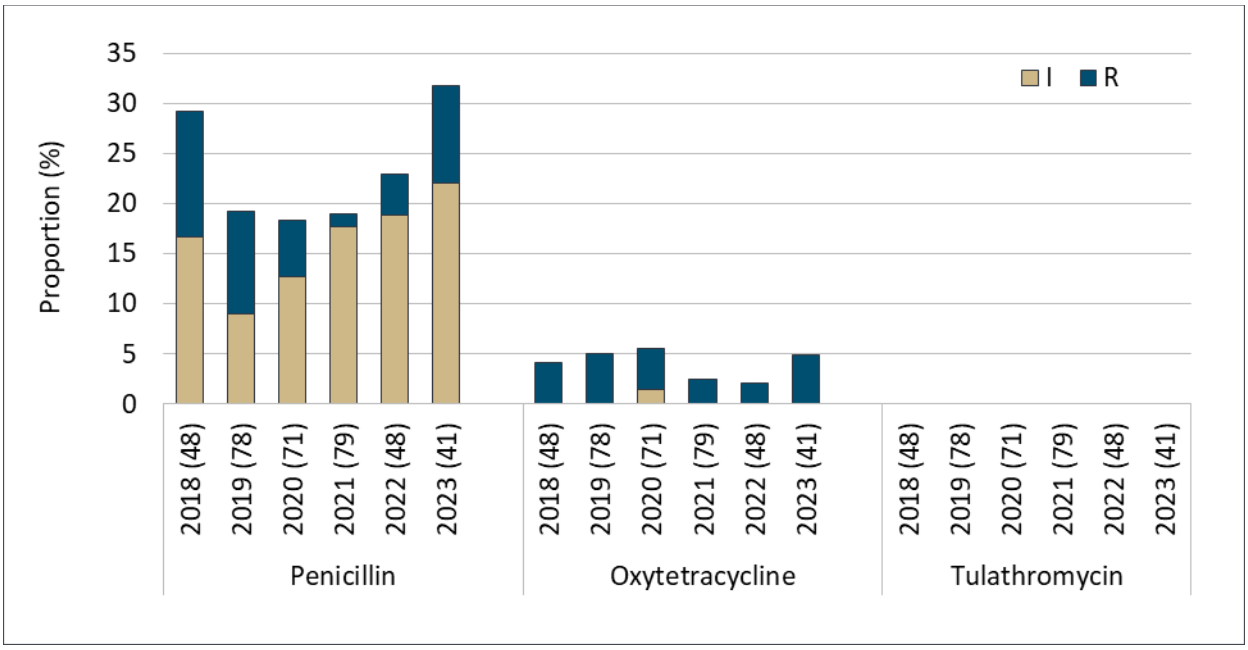

Figure 4.4. *Proportion (%) of M. haemolytica from bovine respiratory disease not susceptible to penicillin, oxytetracycline and tulathromycin in 2018–2023. The number of isolates tested each year are in brackets.*

4.5 *Escherichia coli* from colibacillosis in broilers

Colibacillosis infections in broilers and broiler parents are not treated with antibiotics in Finland. In 2023, altogether 252 strains were isolated from colibacillosis cases representing 130 different farms and 213 different sample submission. No specific colibacillosis outbreaks were noted in 2023, but problems with colibacillosis alone or related to other health issues like IB- virus were frequent, and farmers comprehensively sent clinical samples to the laboratory. Therefore, it can be assumed that the reported resistance rates represent the real situation in *E. coli* strains causing colibacillosis.

Based on epidemiological cut-off values, resistance to trimethoprim, sulfamethoxazole, fluoroquinolones, and tetracycline remained low (Table 4.6, Figure 4.5). Ampicillin resistance in 2023 was markedly higher compared to previous years. This was likely due to results being skewed by an ampicillin resistant strain that was common in 2023. As in previous years (2018–2022), no resistance against 3rd generation cephalosporins was found in 2023. Long term variation in susceptibility is difficult to assess due to the very low number of isolates prior to 2021.

Table 4.6. *Distribution of MICs for Escherichia coli from colibacillosis in 2023 (n=252).*

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	31.3	25.9–37.3							0.4	29.8	36.9	1.6		0.4	31.0					
Cefotaxime	0.0	0.0–1.5			65.1	34.1	0.8													
Ciprofloxacin	1.6	0.6–4.0	65.1	30.6	2.8	1.2	0.4													
Colistin	0.0	0.0–1.5							99.6	0.4										
Sulfamethoxazole[1]	4.8	2.7–8.1										68.3	22.2	3.2	1.6	0.4				4.4
Tetracycline	11.1	7.8–15.6							4.8	46.4	31	6.7	0.4		1.2	8.7	0.8			
Trimethoprim	4.8	2.7–8.1					39.7	43.7	11.1	0.8		4.4		0.4						

Bold vertical lines indicate current (28.5.2024) 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.

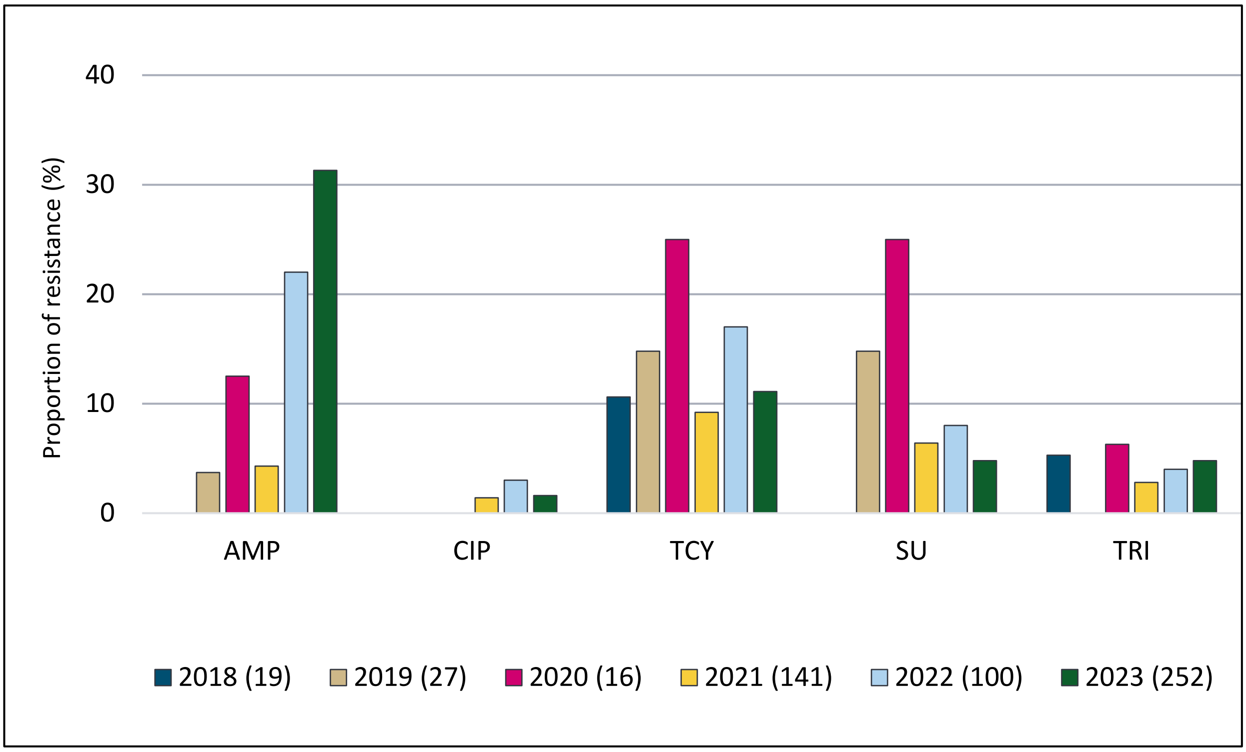

***Figure 4.5**. Antibiotic resistance (%) in E. coli from colibacillosis in the years 2018–2023, epidemiological cut-off values. The number of isolates tested each year are in brackets.*

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

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. Only two isolates from one broiler flock and one parent flock were studied. Both were fully susceptible to all investigated antibiotics. Tenosynovitis is occasionally treated with antibiotics in broiler parent flocks. Production flocks have not been treated with antibiotics since 2010 (Animal Health ETT, 2023).

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 non-susceptibility was reported separately for intermediate and resistant isolates, and updated breakpoints were applied when possible. Statistics for all the reported years were re-evaluated from original data; data inclusion criteria may thus have small differences compared to previous reports, which may cause some variations to proportions of non-susceptible isolates compared to previously reported results. The reporting period covers January 2018 – December 2023 and includes solely bacterial isolates derived from clinical infections. Screening specimens for multiresistant bacteria (MRSA, MRSP, ESBL) were omitted from the analysis. Approximately 33% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 67% 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 5.1), except for penicillin (not shown in figure). In 2023, beta-lactamase results were available for 88 isolates, of which 43% produced penicillinase. This is lower than in the previous years, while the corresponding proportion varied between 60 and 69% in 2018–2023. Non-susceptibility to trimethoprim-sulfamethoxazole increased in 2023 compared to previous years, being almost 3.3% in 2023. Non-susceptibility to clindamycin has remained at the same level as in 2022, being 7.7% in 2023.

Oxacillin resistance (indicating the presence of MRSA among *S. aureus* isolates) has remained at a generally low level during the monitoring period. However, in 2023, the proportion of oxacillin resistance was 8.8%, being the highest during the monitoring period. All eight oxacillin-resistant isolates were from dogs from various infections (ear canal infection, urinary tract infection, superficial pyoderma, and superficial and deep wound/surgical wound infections). Four isolates were of *spa* type t034, while the remaining *spa* types were t233, t2741, t1317 and t091. In 2023, isolates related to the Equine Teaching Hospital (University of Helsinki) MRSA outbreak were not detected from clinical infections from horses.

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.

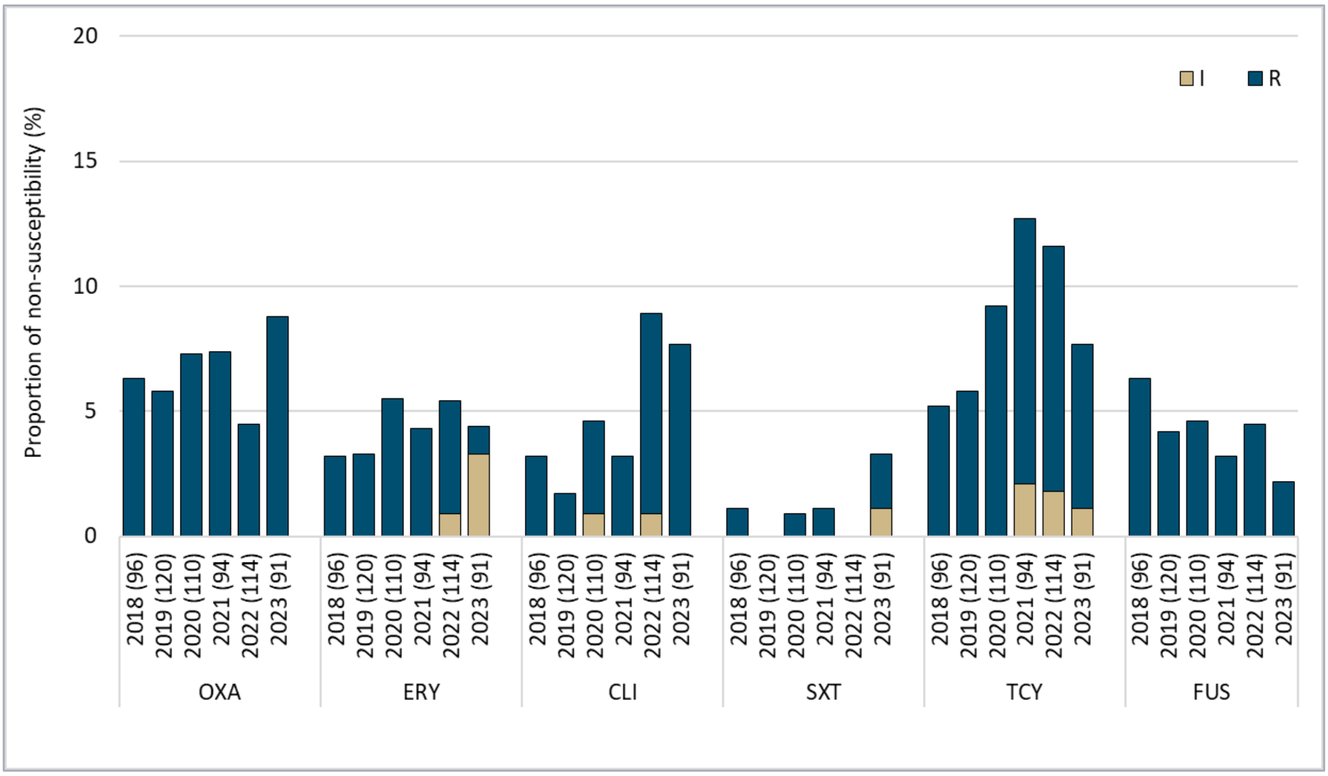

***Figure 5.1**. Antibiotic non-susceptibility (%) in canine, feline, and equine S. aureus in 2018–2023. The number of isolates tested each year are in brackets. In 2023, 55 isolates originated from dogs, 22 from cats, and 14 from horses.*

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 from 6.1% in 2022 to 3.9% in 2023, being at the lowest level since 2018. The proportion has declined drastically during the last eight years: in 2016, the proportion of MRSP was as high as nearly 14% of all *S. pseudintermedius* isolates (see previous FINRES-Vet reports). Penicillinase production remained high as out of the 575 tested *S. pseudintermedius* isolates in 2023, 87% produced penicillinase, which is a larger proportion than among *S. aureus* isolates (p<0.0001).

There have been some changes in the overall non-susceptibility distribution trends of *S. pseudintermedius* isolates in 2023, when compared to the few previous years (Figures 5.2 and 5.3). Macrolide (erythromycin) and lincosamide (clindamycin) non-susceptibilities are now at the highest of the monitoring period, being around 24%. The highest proportion of non-susceptible isolates throughout the whole monitoring period was noted for tetracyclines. Tetracycline and doxycycline resistance levels were both close to 26%. A slightly increasing trend in non-susceptible isolates is detected also for fluoroquinolones over the last four years (enrofloxacin 5% and moxifloxacin approximately 4% in 2023).

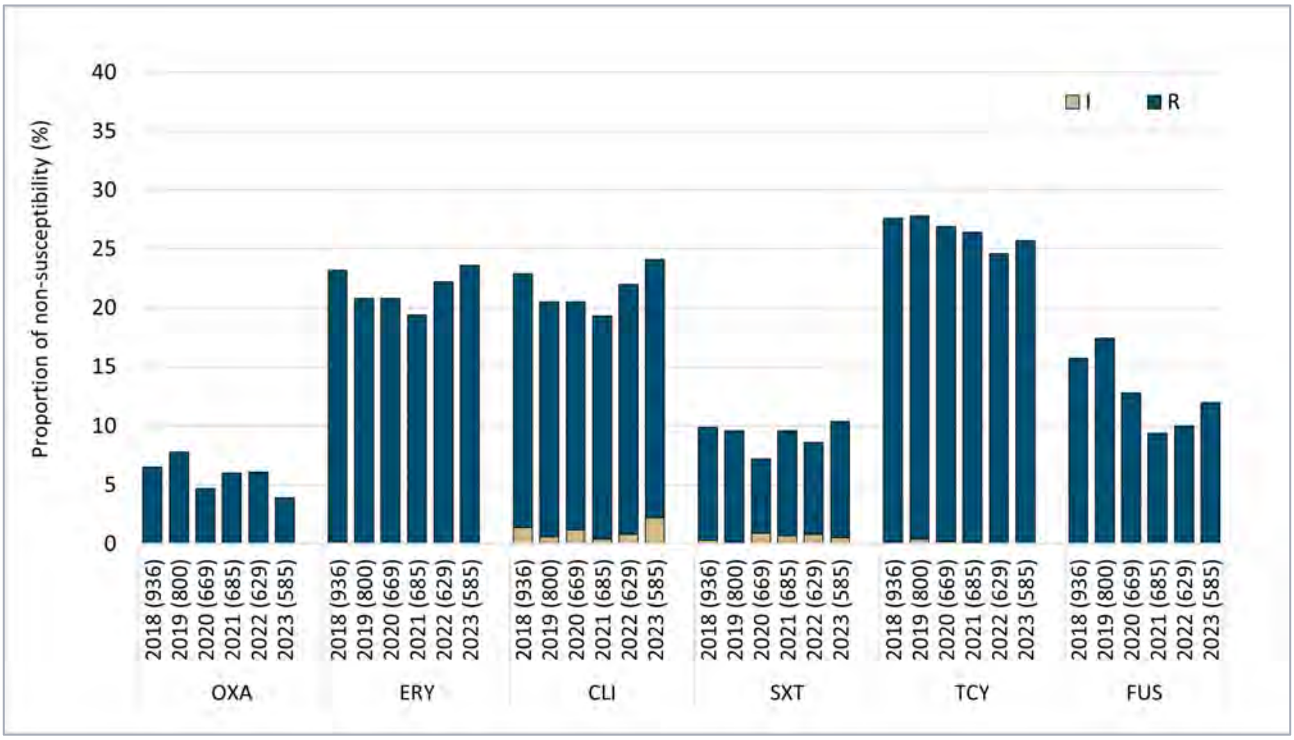

***Figure 5.2**. Antibiotic non-susceptibility (%) for primary antimicrobial agents in canine S. pseudintermedius isolates in 2018–2023. The numbers of isolates tested each year are in brackets.*

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

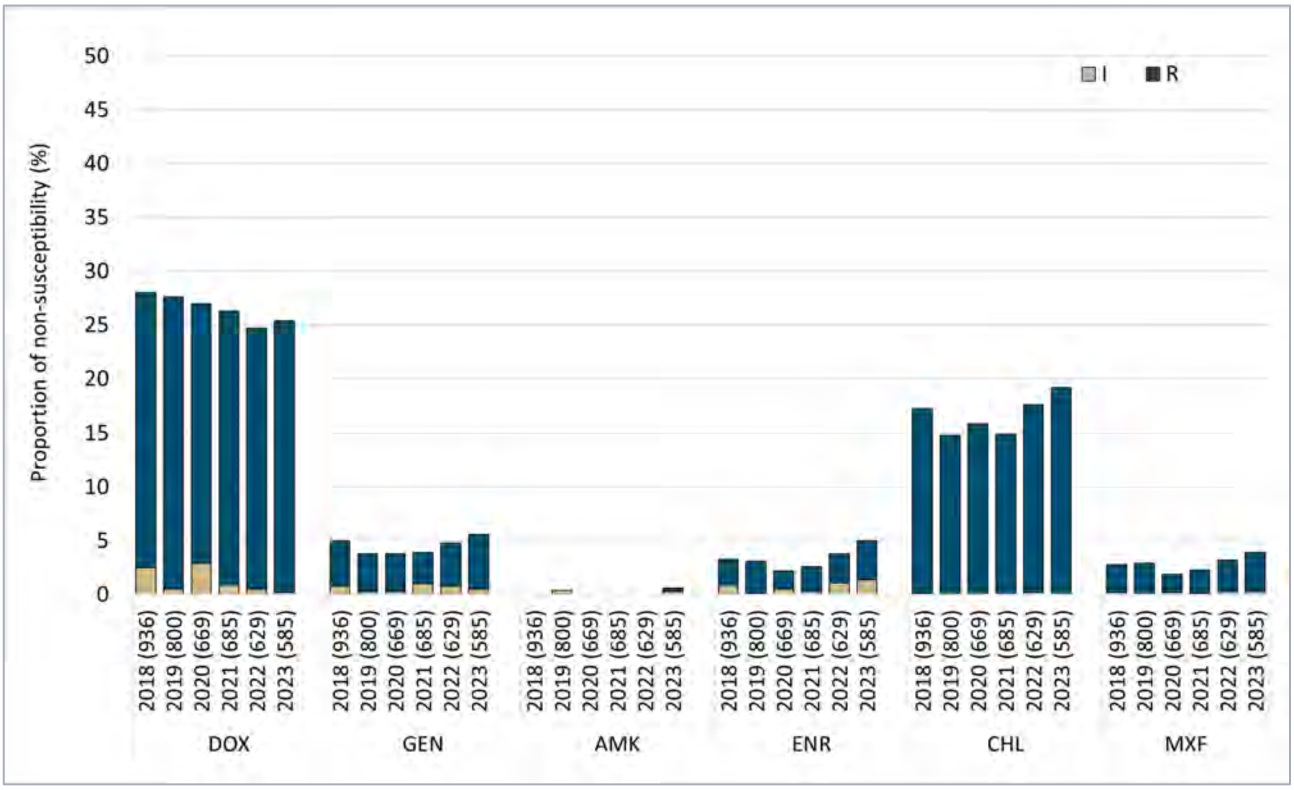

***Figure 5.3**. Antibiotic non-susceptibility (%) for secondary antibiotics in canine S. pseudintermedius isolates in 2018–2023. The number of isolates tested each year are in brackets.*

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, 87% 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 Figures 5.4 and 5.5, respectively. In canine *E. coli* isolates, non-susceptibility to ampicillin slightly decreased in 2023 compared to 2022, while among feline isolates proportion of non-susceptible isolates was highest during the whole study period in 2023. Amoxicillin-clavulanic acid non-susceptibility was slightly increased compared to 2022, for both cats and dogs. In 2023, around 23% of all canine *E. coli* isolates were classified as resistant to ampicillin, and around 4% were resistant to amoxicillin-clavulanic acid, which could implicate that aminopenicillins still could be used in many 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 both canine and feline *E. coli* isolates increased compared to 2022, having been roughly 6.6% in dogs and 4.3% in cats in 2023. Trimethoprim-sulfamethoxazole non-susceptibility in canine and feline *E. coli* fluctuated through the monitoring period, having been 11% in dogs and 3% in cats in 2023.

In 2023, resistance to cefpodoxime increased to 4.4% in canine *E. coli,* having been 2.6% in 2022 (Figures 5.4 and 5.6). Cefpodoxime resistance indicates reduced susceptibility to third generation cephalosporins. The proportion of AmpC-producing isolates increased to 1.6%, and for ESBL-producers to 1.5% (Figure 5.6). The proportion of isolates resistant to cefpodoxime in feline *E. coli* also increased from 2022 (5.3% in 2023, 4.1% in 2022).

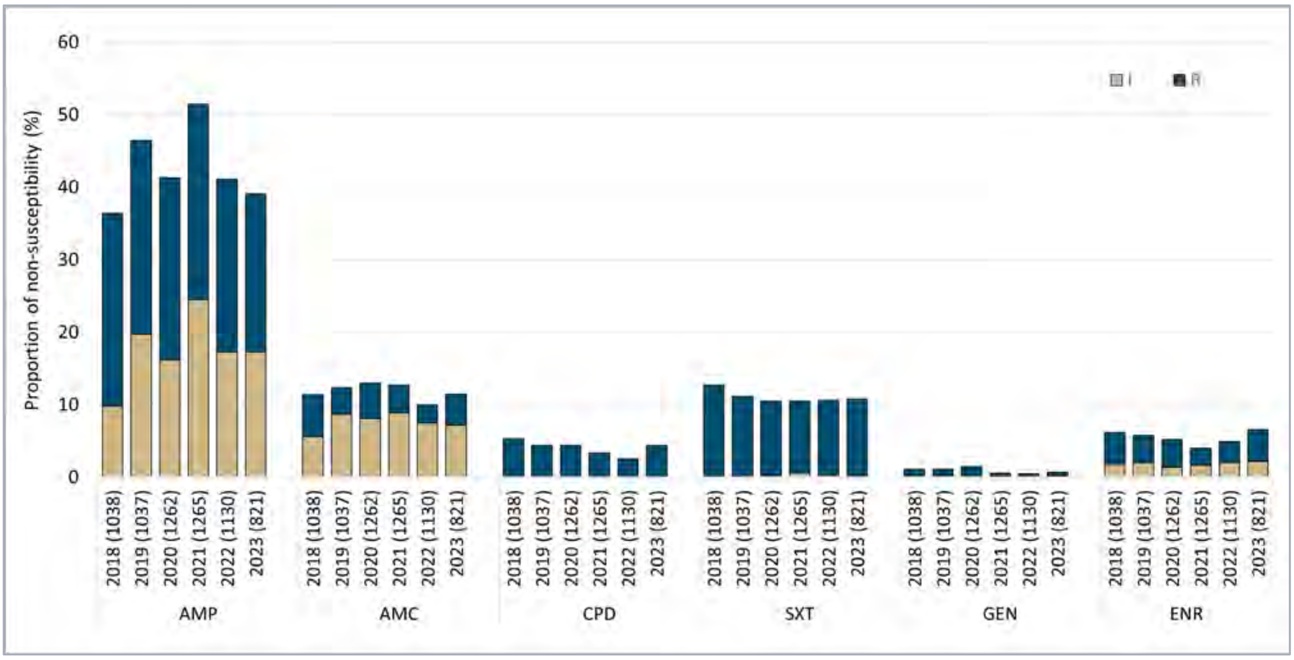

Figure 5.4. *Antibiotic non-susceptibility (%) in canine E. coli in 2018–2023. The number of isolates tested each year are in brackets.*

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

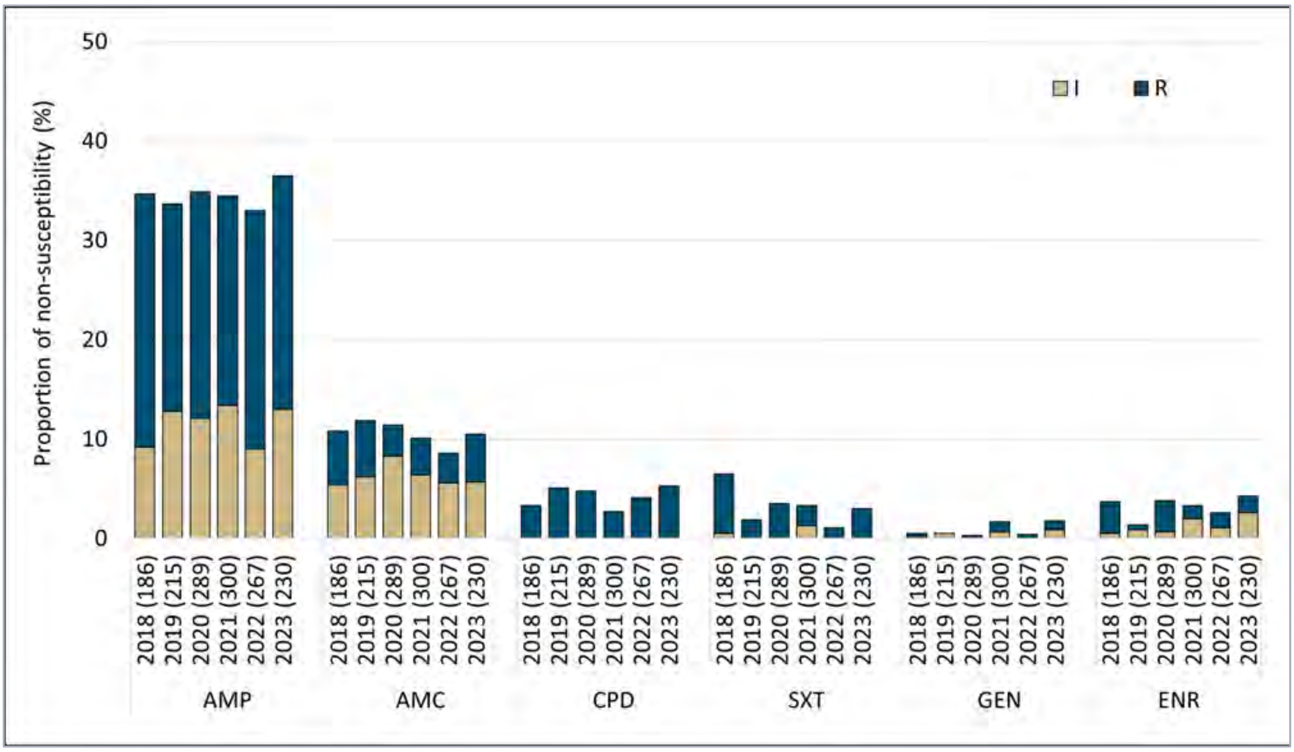

Figure 5.5. *Antibiotic non-susceptibility (%) in feline E. coli in 2018–2023. The number of isolates tested each year are in brackets.*

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

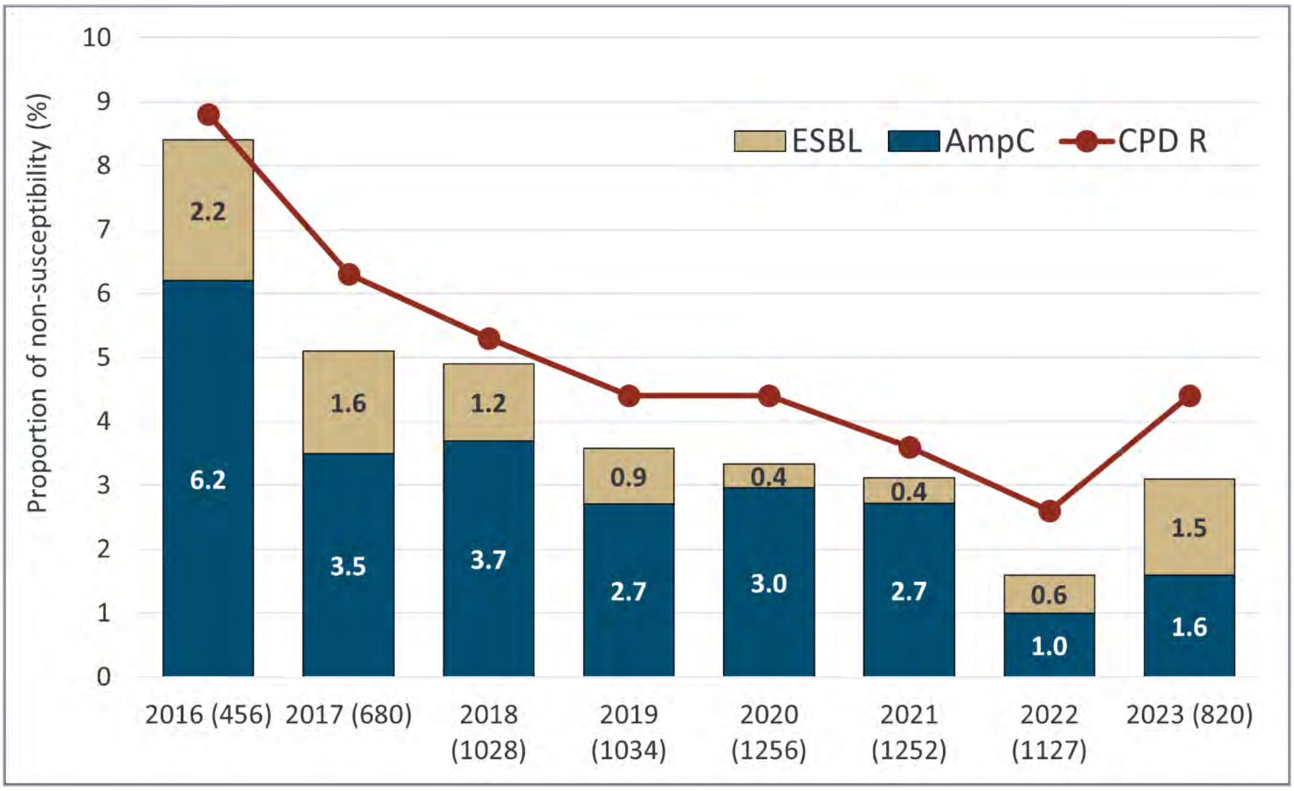

Figure 5.6. *The proportion of isolates with reduced susceptibility to cefpodoxime (CPD), and the proportion of ESBL and AmpC positive isolates in canine E. coli in 2016–2023. The number of isolates tested for CPD each year are in brackets. Only CPD resistant isolates were tested for phenotypic ESBL/AmpC production.*
CPD, cefpodoxime; AmpC and ESBL, extended-spectrum beta-lactamases

5.4 Streptococci from dogs and horses

In 2023, all tested canine *Streptococcus canis* isolates were susceptible to penicillin. For trimethoprim-sulfamethoxazole, proportion of resistant isolates was around 1% and intermediate isolates 2% in 2023 (Figure 5.7). Resistance against this clinically important antimicrobial was absent in 2020 but has recurred since in low ratios. Macrolide (erythromycin) non-susceptibility remained around 10% as in 2022. Clindamycin non-susceptibility increased, while the proportion of resistant isolates was lower than in 2022 (around 7% resistant isolates in 2023 and 11% in 2022). Non-susceptibility to tetracycline increased markedly after several years of decrease, from around 54% in 2022 to 73% in 2023. 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.

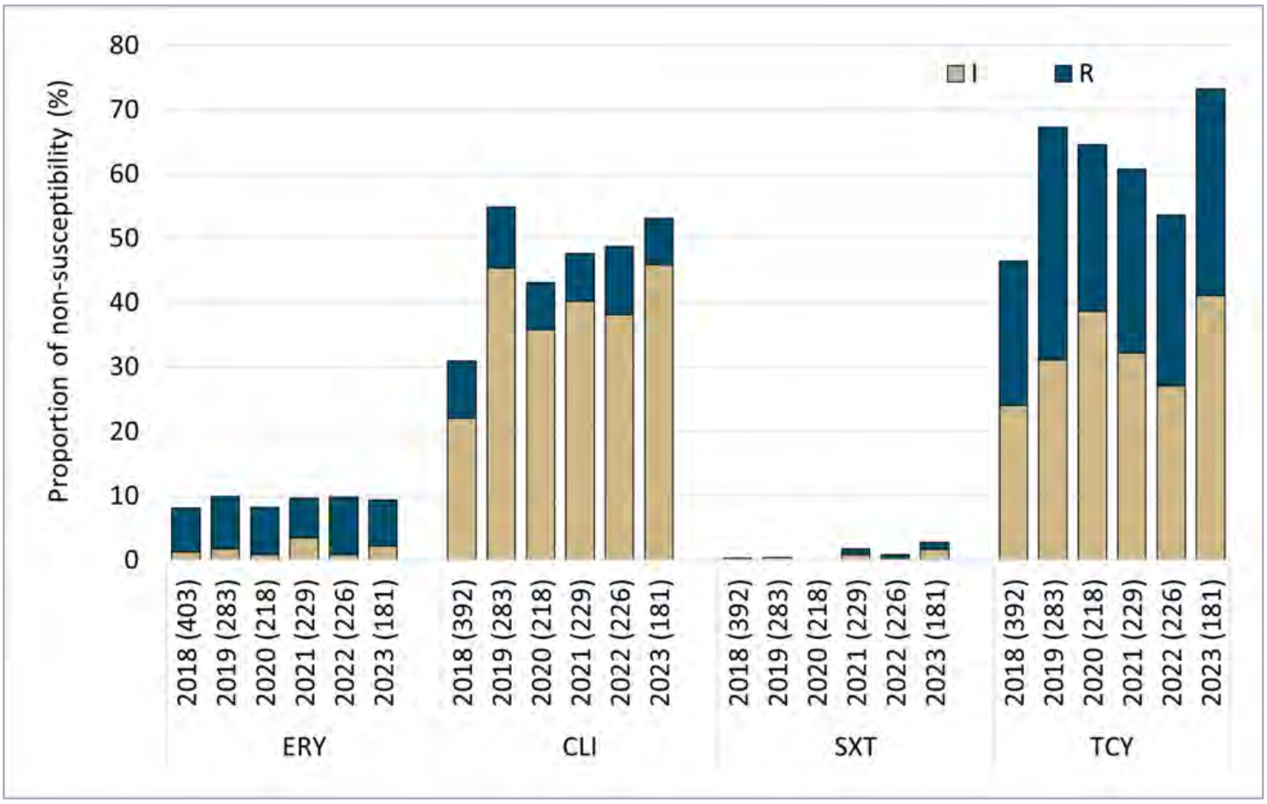

Figure 5.7. *Antibiotic non-susceptibility (%) in canine S. canis isolates in 2018–2023. The number of isolates tested each year are in brackets (isolates tested for tetracycline susceptibility: 351 isolates in 2019, 258 in 2020, 273 in 2021, 252 in 2022, and 209 in 2023).*
ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline

In 2023, 32 *Streptococcus equi* ssp. *zooepidemicus* isolates were found in equine infection specimens. All isolates were susceptible to penicillin. Proportion of non-susceptibility to trimethoprim-sulfamethoxazole decreased slightly compared to the few previous years; proportion of resistant isolates was around 3% in 2023, while it was 7% in 2022 and 9% in 2021 (Figure 5.8). The development of resistance to this antibiotic substance has to be monitored carefully due to its importance in the treatment of many equine infections.

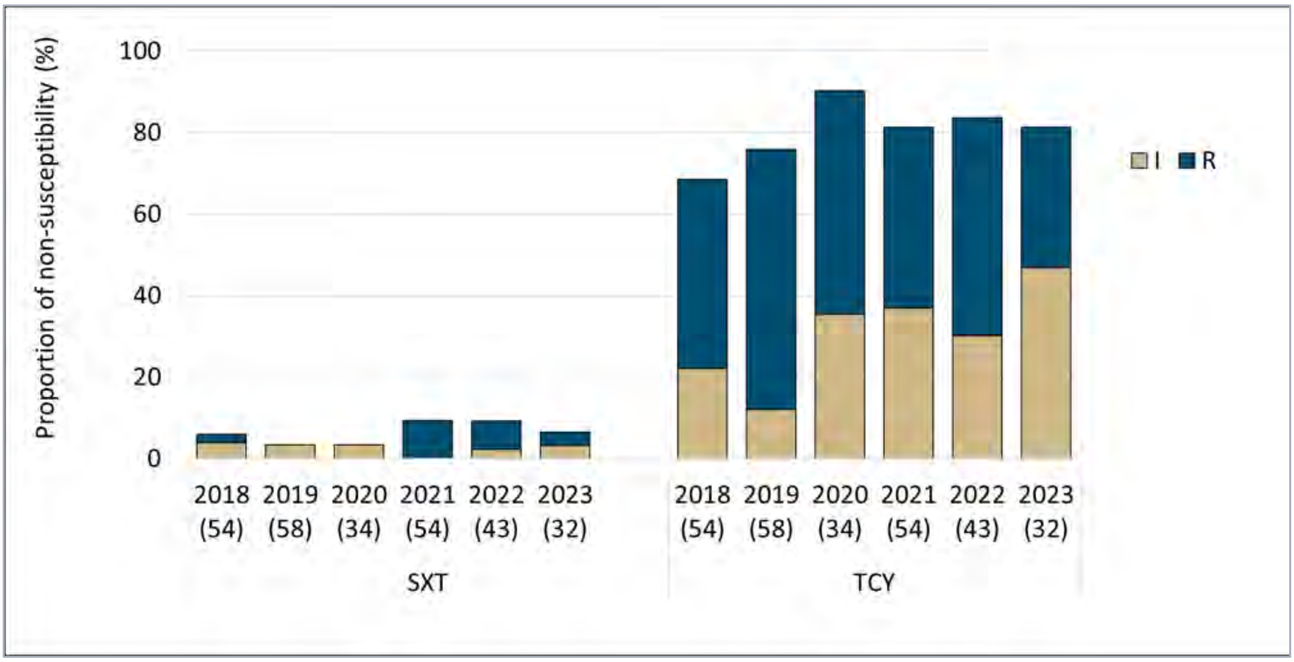

***Figure 5.8**. Antibiotic non-susceptibility (%) in equine S. equi ssp. zooepidemicus isolates in 2018–2023. The number of isolates tested each year are in brackets.*

SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline

5.5 *Pseudomonas aeruginosa* from dogs

In 2023, 56 canine clinical infection isolates of *P. aeruginosa* were tested. Gentamicin non-susceptibility had decreased in 2023, being roughly 13% (22% in 2022) (Figure 5.9). One isolate was classified as resistant to gentamicin and three isolates as intermediate. In 2023, no amikacin-resistant isolates were detected, but there were two intermediate isolates (roughly 4%). Tobramycin-resistant isolates were also not detected, and only one intermediate isolate was present. No resistance to colistin was detected. Non-susceptibility to ciprofloxacin increased, leaving 80% of the isolates susceptible. For enrofloxacin, 32% of the isolates were classified as resistant (82% non-susceptible).

Meropenem non-susceptibility was also detected, with five phenotypically resistant and five intermediate isolates. In previous years, different *bla*OXA genes, indicative of beta-lactamase resistance, have been found in whole genome sequencing of meropenem-non-susceptible canine *P. aeruginosa* isolates. However, it remains unclear whether these genes are the cause of meropenem-resistance in *P. aeruginosa* species.

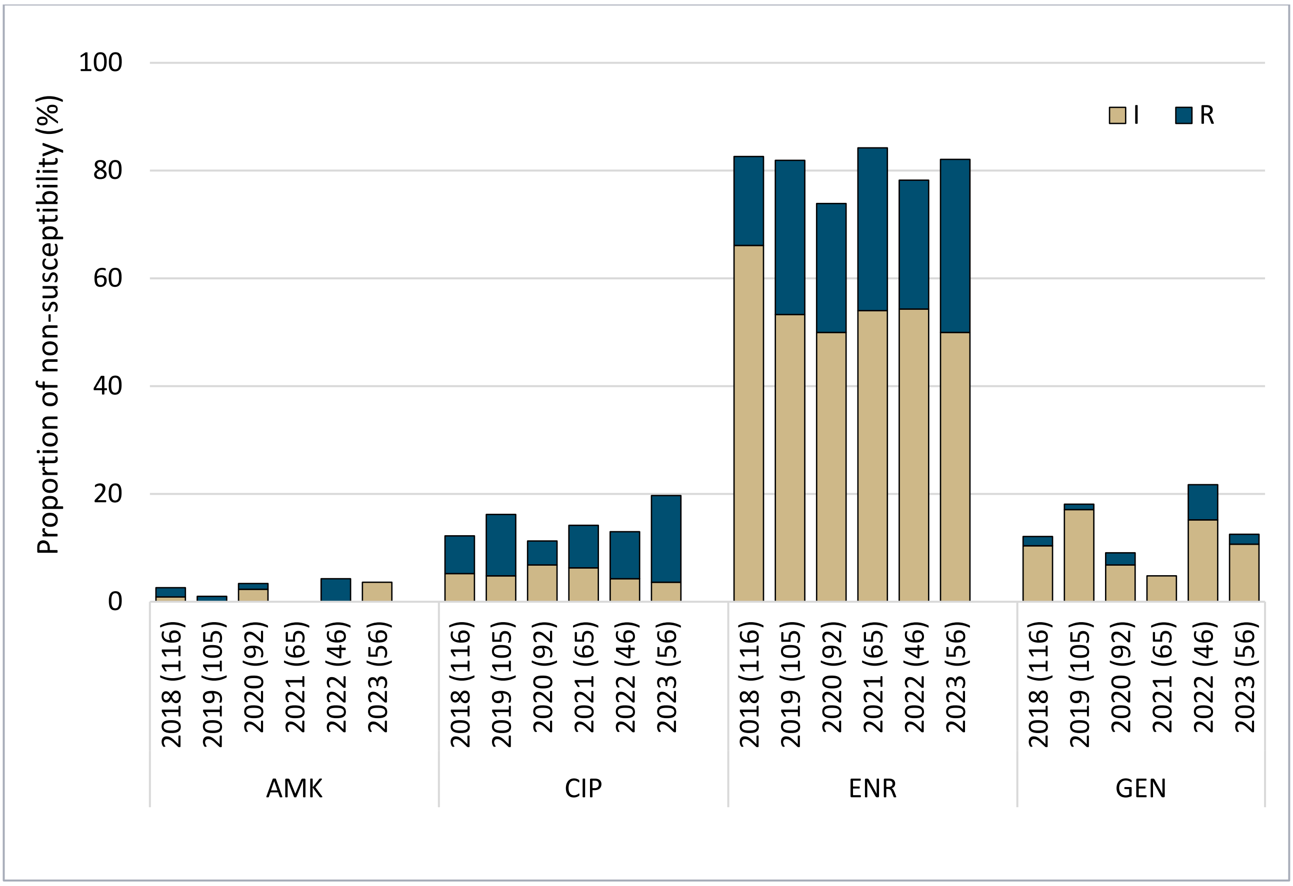

Figure 5.9. *Antibiotic non-susceptibility (%) in canine P. aeruginosa isolates in 2018–2023. The number of isolates tested each year are in brackets.*

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 pigs

In 2023, a total of 170 isolates from pigs were tested for antibiotic susceptibility. Resistance was overall low (Table 6.1) but the majority (69%) of the isolates was fully susceptible to the tested antibiotics (Figure 6.2). However, moderate resistance levels were detected against tetracycline (16.5%), ampicillin (13%), sulfamethoxazole (12%), and trimethoprim (10%) (Table 6.1). Altogether, 6.5% of the isolates were multidrug resistant (Table 6.2). ESBL or AmpC isolates were not detected.

After a mostly decreasing trend of resistance since 2015 there was a slight increase in resistance to tetracycline and a more marked increase in resistance to ampicillin in 2023 (Figure 6.1). Tetracycline resistance has risen from 14 % in 2019 and 12 % in 2021 to 16.5% in 2023. Ampicillin resistance has been less than 10 % in 2017, 2019 and 2021 but increased to 13% in 2023.

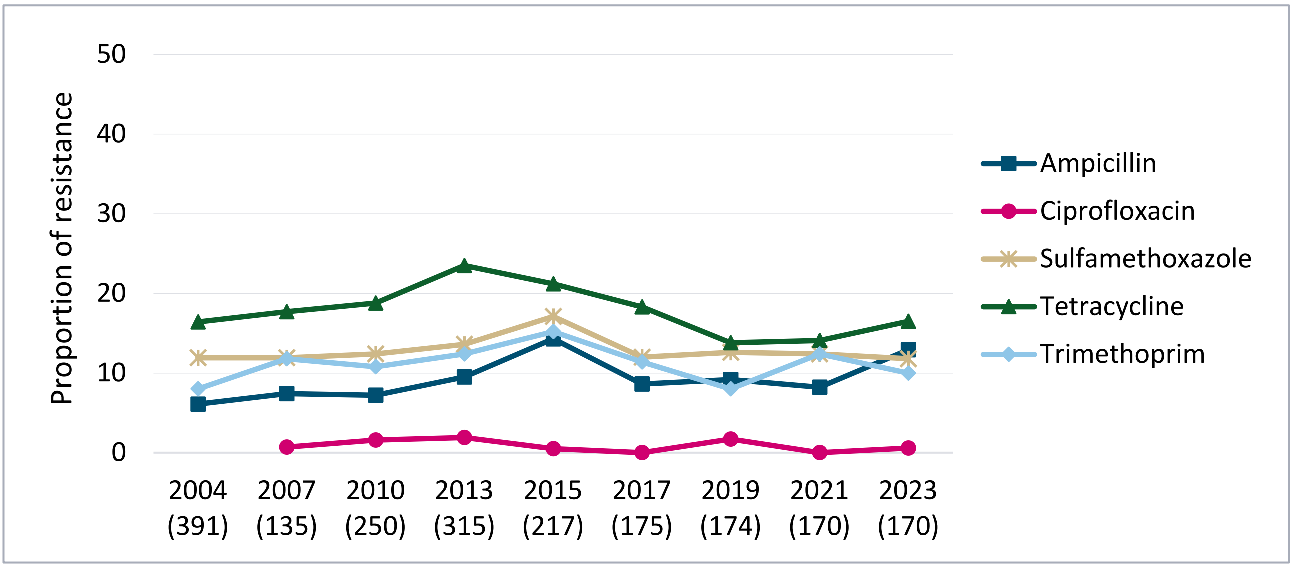

Figure 6.1. *Resistance in indicator E. coli from pigs to selected antibiotics in 2004–2023. The number of isolates tested each year is in brackets.*

Table 6.1. *Distribution of MICs for indicator Escherichia coli in pigs in 2023 (n=170).*

			Distribution (%) of MICs (mg/L)																
Substance	**%R**	**95% C.I.**	**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									94.7	5.3							
Ampicillin	12.9	8.7–18.8								21.2	53.5	12.4			12.9				
Azithromycin[1]	0.0	0.0–2.2								4.7	38.8	56.5							
Cefotaxime	0.6	0.1–3.3					98.8		0.6										
Ceftazidime	0.6	0.1–3.3					90.6	8.2		0.6									
Chloramphenicol	1.2	0.3–4.2										88.8	10.0			1.2			
Ciprofloxacin	0.6	0.1–3.3	88.2	10.6	0.6	0.6													
Colistin	0.0	0.0–2.2							100										
Gentamicin	0.0	0.0–2.2						60.0	36.5	3.5									
Meropenem	0.0	0.0–2.2		100															
Nalidixic acid	0.6	0.1–3.3									99.4			0.6					
Sulfamethoxazole[2]	11.8	7.7–17.5										44.1	35.3	8.8					11.8
Tetracycline	16.5	11.6–22.8								62.4	20.6	0.6			16.5				
Tigecycline	0.0	0.0–2.2					98.8	1.2											
Trimethoprim	10.0	6.3–15.4					35.3	47.6	7.1		0.6			9.4					

Bold vertical lines indicate current (28.5.2024) 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.

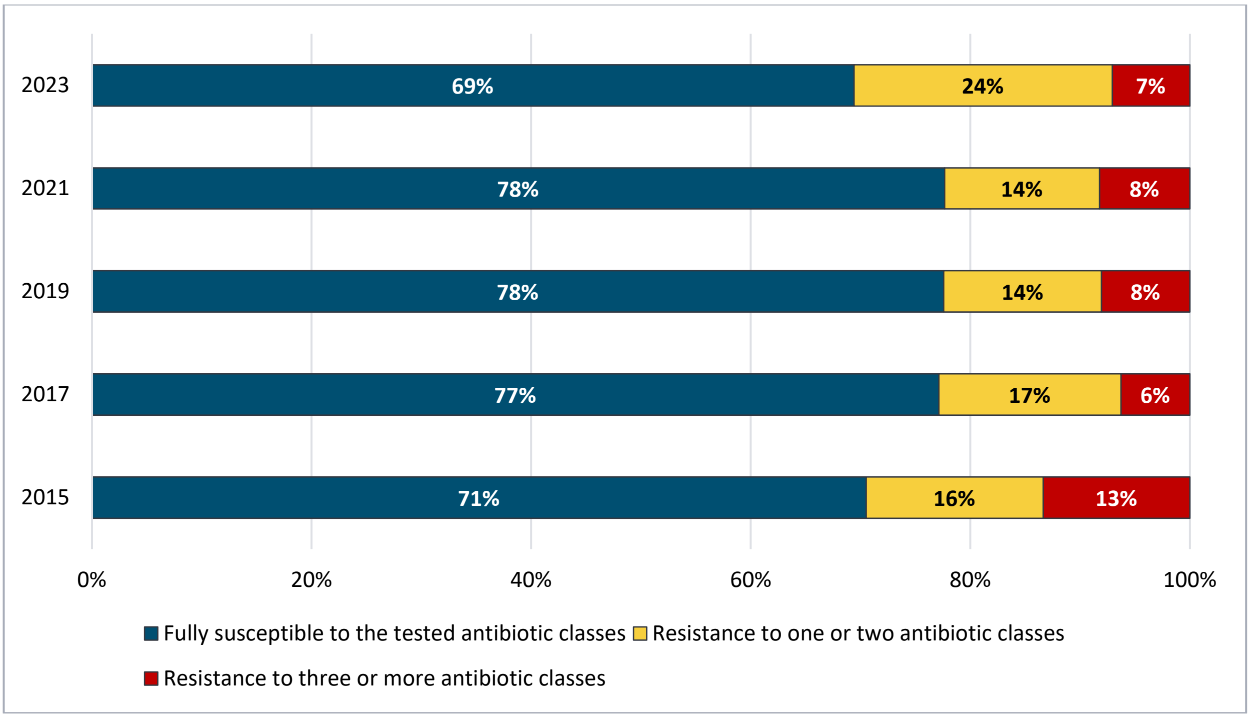

Figure 6.2. *Antibiotic susceptibility of indicator E. coli from pigs at slaughter in Finland between the years 2015 and 2023. The numbers of tested isolates each year are the same as in Figure 6.1. Antibiotic classes included in the analysis: aminoglycosides, beta-lactams, glycylcyclines, phenicols, polymyxins, quinolones, sulfonamides, tetracyclines and diaminopyrimidines (trimethoprim).*

Table 6.2. *Resistance profiles of multidrug resistant indicator E. coli from pigs in 2017, 2019, 2021 and 2023.*

	Nr of isolates in each year			
Resistance profile	**2017**	**2019**	**2021**	**2023**
AMP-TET-SU-TRI-CIP-NAL-CHL		**1**		
AMP-TET-SU-TRI	**5**	**3**	**5**	**4**
AMP-SU-TRI-CHL	**1**			**1**
TET-SU-TRI-NAL	**1**			
AMP-SU-TRI	**2**	**1**	**5**	
AMP-TET-SU	**1**	**3**		
AMP-TET-TRI	**1**			
TET-SU-TRI	**7**	**4**	**4**	
SU-TRI-CHL		**1**		
TET-SU-CIP-NAL		**1**		
AMP-SU	2	4		4
AMP-TET	3		2	1
AMP-CAZ-FOT		1[1]		1
TET-CIP-NAL		1		
TET-SU				1
TET-TRI	1	1	1	1

	Nr of isolates in each year			
Resistance profile	2017	2019	2021	2023
SU-TRI	1	2	6	4
SU-CHL		1		
TRI-CIP				1
AMP		3	2	7
TET	13	10	12	17
SU	1	1	1	1
TRI	1	1		2
NAL				1

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

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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 A1**. Population of food-producing animals as PCU (1000 tonnes) by species in 2014–2023.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cattle	226	229	228	222	220	213	207	205	199	197
Pigs	163	163	161	153	142	142	145	145	141	132
Poultry	68	70	73	76	82	83	85	86	87	84
Sheep and goats	11	13	13	13	13	12	12	11	11	10
Horses	30	30	30	30	30	30	30	30	30	29
Fish	13	15	14	15	14	15	15	14	16	15
TOTAL, PCU	512	520	520	508	500	496	494	491	485	467

***Table A2.** Number of livestock (in thousands) in Finland in 2014–2023.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Dairy cows	285	285	282	275	271	262	260	254	248	242
Suckler cows	58	59	59	60	60	60	62	64	65	65
Cattle > 1 year[1]	268	264	258	261	252	247	235	238	240	233
Calves < 1 year	303	307	310	297	299	288	290	289	281	281
TOTAL, Cattle	914	915	909	893	882	858	846	844	834	821
Boars and sows[2]	NA	127	117	106	104	102	100	100	92	86
Pigs > 3 months and < 8 months	NA	579	575	536	508	495	496	504	477	452
Piglets < 3 months	NA	537	542	494	477	475	490	503	492	451
TOTAL, pigs	1 245	1 243	1 235	1 136	1 089	1 072	1 087	1 108	1 061	988
Laying hens	3 645	3 595	3 599	3 746	3 985	3 900	3 812	3 729	3 866	4056
Chicks	714	662	748	509	608	647	566	796	665	569
Broilers	7 341	7 827	8 272	8 047	8 781	9 112	8 507	8 499	8 901	8718
Turkeys	292	246	260	292	299	263	268	287	283	272
Other poultry[3]	584	597	566	543	468	438	424	520	641	664
TOTAL, poultry	12 577	12 927	13 445	13 136	14 140	14 360	13 577	13 831	14 356	14 279

[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 May. Number of pigs and poultry 1 Apr. Number of poultry in 2016 not totally comparable with the previous years. Source: OFS: Luke, Number of livestock.

Table A3. *Number of farms in Finland in 2014–2023.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cattle farms	12 885	12 389	11 791	11 175	10 530	9 851	9 301	8 787	8 211	7747
Pig farms	1 486	1 337	1 240	1 102	1 027	963	918	864	798	692
Poultry farms	1 299	1 310	1 300	1 280	1 243	1 172	1 201	553	475	445

Source: OFS: Luke, Number of livestock.

Table A4. *The production of meat and fish (million kg) in Finland in 2014–2023.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Beef[1]	83	86	87	86	87	88	87	86	84	85
Pork[1]	186	192	190	182	169	171	176	176	170	159
Poultry[1]	113	117	125	129	135	139	145	147	147	144
Total	383	397	403	397	391	398	408	409	401	388
Fish[2]	13	15	14	15	14	15	15	15	16	15

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

Table A5. *The production of milk in Finland in 2014–2023.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Milk production; per animal (litres)	8 201	8 323	8 406	8 534	8 650	8 810	9 038	8 924	8 888	9043
Total milk production (million litres)	2 330	2 365	2 359	2 336	2 328	2 305	2 336	2 247	2 193	2174

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

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

Table A6. *Overall sales of veterinary antibiotics in Finland in 2014–2023, kg active ingredient.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Tetracyclines	2 576	2 250	2 010	2 268	2 218	2 677	1 830	1 780	1 248	1 592
Amphenicols	84	80	87	104	112	117	109	124	110	104
Penicillin G and V	4 231	4 058	3 544	3 771	3 805	3 705	3 824	3 918	3 661	3 556
Aminopenicillins	1 374	1 498	1 438	1 160	1 020	1 011	934	1 012	826	851
Cloxacillin	91	65	63	45	39	33	39	48	36	31
1^{st} gen. cephalosporins[1]	727	605	513	355	284	227	184	169	129	110
3^{rd} gen. cephalosporins	8	7	3	1	0.5	0.2	0.2	0.2	0.2	0.1
Sulfonamides and trimethoprim	2 893	2 445	2 460	2 216	1 870	2 119	1 646	1 980	1 685	1 781
Macrolides	521	596	517	408	411	221	192	190	106	118
Lincosamides	189	165	120	297	184	197	61	56	54	58
Aminoglycosides	101	93	87	73	61	59	42	27	21	24
Fluoroquinolones	113	94	99	80	81	66	70	69	60	59
Pleuromutilins	44	30	23	14	10	3	2	0	0	0
Others							0	5	7	6
Total sales	**12 954**	**11 987**	**10 964**	**10 790**	**10 095**	**10 435**	**8 933**	**9 378**	**7 979**	**8 290**

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

Table A7. *Sales of injectable veterinary antibiotics in Finland in 2014–2023, kg active ingredient.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Tetracyclines	552	640	686	671	642	741	644	602	540	505
Amphenicols	17	6	13	26	15	23	24	25	16	25
Penicillin G*	3 981	3 781	3 230	3 538	3 564	3 479	3 565	3 692	3 484	3 320
Aminopenicillins	416	473	453	338	286	279	229	271	215	214
1^{st} gen. cephalosporins	0	0	5	1	1	0	0	0	0	0
3^{rd} gen. cephalosporins	8	7	3	1	0.5	0.2	0.2	0.2	0.2	0.1
Sulfonamides and trimethoprim	358	373	322	317	286	292	252	213	202	177
Macrolides	12	15	19	13	10	9	9	7	5	5
Lincosamides	26	26	25	19	18	19	24	21	23	26
Aminoglycosides	15	13	14	12	10	10	12	7	6	7
Fluoroquinolones	90	72	78	63	66	50	56	55	47	46
Total sales	**5 475**	**5 406**	**4 849**	**4 999**	**4 899**	**4 902**	**4 815**	**4 893**	**4 538**	**4 325**

**Sales of penicillin G in 2022 corrected*

Tables A8-A and A8-B. *Sales of orally administered veterinary antibiotics (premixes, oral solutions, oral powders and oral pastes) and sales of veterinary antibiotic tablets by class in Finland 2014-2023, kg active ingredient.*

A8-A. *Sales of orally administered products excluding veterinary antibiotic tablets 2014-2023, kg active ingredient. Others = 1st generation cephalosporins and fluoroquinolones for use in companion animals.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Tetracyclines	2 024	1 610	1 324	1 597	1 575	1 936	1 186	1 173	735	1 074
Amphenicols	67	74	74	78	97	94	85	99	94	79
Penicillin V	122	147	190	100	105	94	118	92	53	90
Aminopenicillins	50	123	82	44	47	22	45	19	48	10
Sulfonamides and trimethoprim	2 411	2 072	2 138	1891	1557	1 813	1 382	1 724	1 458	1 551
Macrolides	510	581	498	395	402	212	183	182	101	113
Lincosamides	109	91	48	238	131	146	< 1	< 1	< 1	0
Pleuromutilins	44	30	23	14	10	3	2	0	0	0
Others	4	3	2	2	2	2	2	1	< 1	0
Total sales	**5 341**	**4 731**	**4 379**	**4 359**	**3 925**	**4 322**	**3 002**	**3 290**	**2 490**	**2 917**

A8-B. *Sales of orally administered veterinary antibiotic tablets 2014-2023, kg active ingredient. Others = tetracyclines, aminoglycosides and imidazole derivatives.*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Aminopenicillins	897	894	894	769	681	707	656	721	562	626
1st gen. cephalosporins	701	584	491	339	272	218	180	168	129	110
Sulfonamides and trimethoprim	124	0	0	8	27	14	12	44	25	53
Lincosamides	54	48	46	39	34	33	37	34	31	33
Fluoroquinolones	22	22	21	16	15	15	14	14	13	13
Others	70	62	54	41	32	29	8	10	15	19
Total sales	**1 869**	**1 611**	**1 507**	**1 212**	**1 060**	**1 016**	**908**	**991**	**775**	**853**

Tables A9-A and A9-B. *Sales of intramammaries for veterinary use in Finland 2014-2023, kg active ingredient*

A9-A. *Intramammaries for lactation phase*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Penicillin	93	88	80	86	91	87	93	90	87	106
Aminopenicillins	8	7	7	6	5	3	4	1	1	1
Cephalexin	22	18	15	13	9	8	2	0	0	0
Cloxacillin	41	31	29	19	18	15	25	23	19	17
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	**164**	**144**	**131**	**123**	**123**	**113**	**124**	**114**	**108**	**125**

A9-B. *Intramammaries for dry cow period*

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Penicillin	35	41	44	47	45	45	49	45	36	40
Aminopenicillins	3	2	2	3	1	0	0	0	0	0
Cephalexin	0	0	0	0	0	0	0	0	0	0
Cloxacillin	50	35	34	26	21	18	14	26	17	14
Aminoglycosides	15	18	19	20	20	20	21	19	15	17
Total dry cow	**104**	**96**	**100**	**97**	**87**	**83**	**85**	**90**	**68**	**71**

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 and the samples were then combined. All isolates (one isolate per flock) were included in the antibiotic susceptibility testing.

Campylobacter from pigs were isolated between February and December from healthy animals at slaughter from the three biggest slaughterhouses that accounted for >98% of all pigs slaughtered in Finland. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. From each epidemiological unit (slaughter batch) a caecal sample was taken from one animal. If several samples from the same epidemiological unit were taken only one sample was analysed further. The samples were taken aseptically and transported refrigerated to the laboratory within two days. Samples were collected between Monday and Thursday. One campylobacter isolate from each epidemiological unit (if available) was selected for susceptibility testing.

Animal pathogens

Clinical isolates originated from diagnostic submissions or post-mortem examinations done in the laboratories of 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 fecal samples of swine with diarrhea.

Antibiotic resistance figures from companion animal pathogens were collected from the Clinical Microbiology Laboratory of the Veterinary Teaching Hospital, 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 caecal samples from pigs in 2023. From the same samples, ESBL/AmpC and carbapenemase producing *E. coli* were screened. The samples from pigs (n=300) originated from healthy animals at slaughter between January and December. 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 >98% of all pigs slaughtered in Finland. Sampling was evenly distributed throughout the study period. From each epidemiological unit (slaughter batch), one sample was taken from one animal. The samples were taken aseptically and transported refrigerated to the laboratory within 2 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. All presumptive ESBL/AmpC/carbapenemase producing E. coli (n=19) were also subjected to whole-genome sequencing. The guidelines of the EURL-AR protocol version 2.2 for whole-genome sequencing and bioinformatic analysis of bacterial isolates related to the EU monitoring of antimicrobial resistance were followed using an in-house equipment (Illumina MiSeq) and workflow. The library was prepared using Illumina DNA Prep kit following the manufacturer's instructions. Analysis of the antimicrobial resistance genes was performed using ResFinder 4.5.0 (https://www.genomicepidemiology.org/services/).

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 moisturized 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) pork (n=302) and beef (n=299) were collected at retail between January and December in 2023. The majority of the samples were of domestic origin (99% of the pork and 91% of the beef samples). Sampling was evenly distributed throughout the study period and allocated according to meat batches. Samples collected from retail shops were obtained from eight different NUTS-3 areas, covering approximately 72% of the Finnish population. From the NUTS-3 areas included in the sampling, the number of samples to be collected was proportional to the inhabitant size. 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. 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.
All presumptive ESBL/AmpC/carbapenemase producing E. coli (n=1) were also subjected to whole-genome sequencing. The guidelines of the EURL-AR protocol version 2.2 for whole-genome sequencing and

bioinformatic analysis of bacterial isolates related to the EU monitoring of antimicrobial resistance were followed using an in-house equipment (Illumina MiSeq) and workflow. The library was prepared using Illumina DNA Prep kit following the manufacturer's instructions. Analysis of the antimicrobial resistance genes was performed using ResFinder 4.5.0 (https://www.genomicepidemiology.org/services/).

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.

C. coli and *C. jejuni* from pigs were isolated and confirmed at the Finnish Food Authority, in the Microbiology Unit, according to ISO 10272-1:2017 with modifications mentioned in Statens veterinärmedicinska anstalt (SVA) protocol for isolation, identification and storage of *Campylobacter jejuni* and/or *C. coli* for the EU monitoring of antimicrobial resistance (version 1, 2020).

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 Veterinary Teaching Hospital, 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

Pig caecal samples (n=300) taken at slaughterhouses, fresh pork (n=302) and beef (n=299) samples taken at retail, were screened as part of the EU-wide monitoring based on Commission Implementing Decision (EU) 2020/1729 according to the EURL laboratory protocol Isolation of ESBL-, AmpC and carbapenemase-producing *E. coli* from caecal samples version 7, Dec 2019. 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 Animal Health Diagnostic Unit. Current (28.5.2024) 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 A10). 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 A10. *Cut-off values (mg/L) for resistance used in this report. Values represent EUCAST epidemiological cut-offs (ECOFFs) (28.5.2024). If EUCAST ECOFF was missing or different cut-off value was used, it is stated in the footnote.*

Substance	***Salmonella enterica***	***Escherichia coli***	***Campylobacter coli***	***Campylobacter jejuni***	***Staphylococcus aureus***
Amikacin	>4[1]	>8			
Ampicillin	>4	>8			
Azithromycin	>16	>16[1]			
Cefotaxime	>0.5[1]	>0.25			
Cefoxitin					>4

Substance	*Salmonella enterica*	*Escherichia coli*	*Campylobacter coli*	*Campylobacter jejuni*	*Staphylococcus aureus*
Ceftazidime	>2	>1			
Chloramphenicol	>16	>16	>16	>16	
Ciprofloxacin	>0.125[1]	>0.06	>0.5	>0.5	
Colistin	[2]	>2			
Enrofloxacin		>0.125			
Ertapenem			[2]	>0.125[1]	
Erythromycin			>8	>4	
Florfenicol		>16			
Gentamicin	>2	>2	>2	>2	
Meropenem	>0.125[3]	>0.06			
Nalidixic acid	>8	>8			
Streptomycin		>16			
Sulfamethoxazole	>256[3]	>64[3]			
Tetracycline	>8	>8	>2	>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 Veterinary Teaching Hospital 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 7th ed (CLSI, 2024) was used to calculate non-susceptibility (intermediate and resistant) percentages. If veterinary breakpoints were not available, the breakpoints available in CLSI M100-S24 (CLSI, 2014) and CLSI M100 34th ed (CLSI, 2024) were used. Exceptions were fusidic acid non-susceptibility breakpoint, which was ≤ 23 (EUCAST, 2024), and *S. pseudintermedius* non-susceptibility breakpoint for oxacillin, ≤ 19 (EUCAST, 2024). Beta-lactamase activity was tested with Cefinase™ disks (Becton Dickinson, NJ, USA). *S. aureus* with reduced susceptibility to oxacillin or cefoxitin 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^{TM} 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 Veterinary Teaching Hospital 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 2023

Table A11. *Salmonella enterica serovars isolated from the main food-producing animal species in Finland in 2023.*

Serotype	Nr of isolates	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	21	11	5	5	
S. Enteritidis	7	6	1		
S. Derby	1		1		
S. Dublin	1		1		
S. Heidelberg	1	1			
S. Hessarek	3	1	2		
S. Kentucky	1	1			
S. Konstanz	2	2			
S. Uganda	5		5		
S. ssp. IIIb (= diarizonae)	2	1		1	
Sum	**44**	**23**	**15**	**6**	**0**

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