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FINRES-Vet 2016–2017

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

Fimea
Finnish Medicines Agency

UNIVERSITY OF HELSINKI
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Acknowledgements
The coordinators of the FINRES-Vet programme wish to thank the meat inspection personnel of Evira and slaughterhouses for collecting the samples from animals at slaughter. Also, the personnel of Evira who has participated in the meat sampling at retail are acknowledged.

This report is available at www.evira.fi

Description

Publisher	Finnish Food Safety Authority Evira
Title	FINRES-Vet 2016–2017. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Authors	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Merja Rantala, Tarja Pohjanvirta, Mia Biström, Mirja Raunio-Saarnisto, Thomas Grönthal, Martti Nevalainen, Liisa Kaartinen, Henriette Helin-Soilevaara, Katariina Pekkanen
Abstract	Changes in the number of food-producing animals during 2016–2017 were relatively small.The overall sales of veterinary antimicrobials were 11 000 kg in 2017 which is the lowest ever recorded in Finland. Decreases were observed in the sales of both orally used and injectable products. Especially the sales of tablets intended for companion animals show a strong decreasing trend in recent years. The proportion of highest priority critically important antimicrobials (HPCIA) continued to be very low, nevertheless, a significant decrease was seen for 3rd generation cephalosporins. Majority of the veterinary antimicrobials were for individual use (65%) and penicillin G continued to be the most sold antimicrobial. The occurence of antimicrobial resistance in bacteria from animals and food has remained relatively good in Finland. However, in certain bacteria resistance was detected in moderate or high levels. Therefore, there is a need to further emphasise the preventive measures and prudent use of antimicrobials. It is important to obey the Finnish recommendations for the use of antimicrobials in animals. Among campylobacter and salmonella, resistance levels were mainly low. Fluoroquinolone resistance detected in campylobacter during the last decade did not continue to increase any more. Among pathogenic bacteria isolated from production animals the most notifiable change was the worsening of resistance in some bovine respiratory disease pathogens. In other pathogens from production animals the resistance situation remained similar as in previous years. The proportion of resistant bacterial isolates from companion animals and horses decreased for nearly all antibiotics. However, the number of resistant isolates remains high for some antibiotics. ESBL/AmpC bacteria were mostly encountered in broilers and broiler meat but rarely or not at all in pigs, cattle, pork or beef. The prevalence of MRSA in pig slaughter batches was very high while these bacteria occured in pork meat in a relatively low level.
Publication date	December 2018
Keywords	Antimicrobial resistance, consumption of antimicrobials
Name and number of publication	Evira publications 5/2018
Pages	57
Language	English
Confidentiality	Public
Publisher	Finnish Food Safety Authority Evira
Layout	Finnish Food Safety Authority Evira, In-house Services Unit
	ISSN 1797-299X, ISBN 978-952-225-173-2 (pdf)

Kuvailulehti

Julkaisija	Elintarviketurvallisuusvirasto Evira
Julkaisun nimi	FINRES-Vet 2016–2017. Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Tekijät	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Merja Rantala, Tarja Pohjanvirta, Mia Biström, Mirja Raunio-Saarnisto, Thomas Grönthal, Martti Nevalainen, Liisa Kaartinen, Henriette Helin-Soilevaara, Katariina Pekkanen
Tiivistelmä	Tuotantoeläinten määrässä ei tapahtunut suuria muutoksia vuosina 2016-2017. Eläinten mikrobilääkkeiden kokonaismyynti Suomessa vuonna 2017 oli 11 000 kg eli matalampi kuin koskaan aikaisemmin. Sekä suun kautta annettavia että injektiovalmisteita myytiin aikaisempaa vähemmän. Varsinkin seuraeläinten tablettien myynti on vähentynyt selvästi viime vuosina. Kriittisen tärkeiden mikrobilääkkeiden osuus pysyi erittäin pienenä. Siitä huolimatta kolmannen polven kefalosporiinien myynti väheni huomattavasti. Suurin osa mikrobilääkkeistä annettiin eläinyksilöille (65 %) ja penisilliini G oli edelleen eniten myyty eläinten mikrobilääke. Eläimistä ja elintarvikkeista eristettyjen bakteerien mikrobilääkeresistenssitilanne Suomessa on edelleen suhteellisen hyvä. Joillakin bakteereilla resistenssiä kuitenkin esiintyy kohtalaisesti tai yleisesti, joten eläinten mikrobilääkkeiden käyttötarpeen vähentämiseen ja hallittuun mikrobilääkkeiden käyttöön tulee edelleen kiinnittää huomiota. Eläimille annettuja mikrobilääkkeiden käyttösuosituksia on syytä noudattaa. Kampylobakteereilla ja salmonelloilla resistenssiä todettiin pääasiassa vähän. Viime vuosikymmenen aikana kampylobakteereilla yleistyneessä fluorokinoloniresistenssissä ei enää havaittu nousua. Tuotantoeläimille tautia-aiheuttavien patogeenien resistenssitilanteen kannalta merkittävin muutos aiempiin vuosiin oli joidenkin nautojen hengitystiepatogeenien resistenssitilanteen huonontuminen. Muuten tuotantoeläinten patogeenien resistenssitilanteessa ei todettu merkittäviä muutoksia. Seura- ja harrastuseläimistä eristettyjen bakteerien joukossa resistenssi väheni seurantajakson aikana lähes kaikkien mikrobilääkkeiden suhteen. Tiettyjen lääkeaineiden osalta resistenttien kantojen osuus on kuitenkin vielä korkea. ESBL/AmpC-bakteereita esiintyi edelleen eniten broilereilla ja broilerinlihassa, mutta hyvin vähän tai ei ollenkaan sioissa, naudoissa sekä sian- ja naudanlihassa. MRSA-bakteerien esiintyvyys sikojen teuraserissä on erittäin yleistä, mutta sianlihassa niitä todetaan suhteellisen vähän.
Julkaisuaika	Joulukuu 2018
Asiasanat	Mikrobilääkeresistenssi, mikrobilääkkeiden käyttö
Julkaisusarjan nimi ja numero	Eviran julkaisuja 5/2018
Sivuja	57
Kieli	Englanti
Luottamuksellisuus	Julkinen
Julkaisun kustantaja	Elintarviketurvallisuusvirasto Evira
Taitto	Elintarviketurvallisuusvirasto Evira, käyttäjäpalvelujen yksikkö
	ISSN 1797-299X, ISBN 978-952-225-173-2 (pdf)

Beskrivning

Utgivare	Livsmedelssäkerhetsverket Evira
Publikationens titel	FINRES-Vet 2016–2017 Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents
Författare	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Merja Rantala, Tarja Pohjanvirta, Mia Biström, Mirja Raunio-Saarnisto, Thomas Grönthal, Martti Nevalainen, Liisa Kaartinen, Henriette Helin-Soilevaara, Katariina Pekkanen
Resumé	De fanns inga stora förändringar in antalet productionsdjur. Den totala försäljningen av antimikrobiella läkemedel för djur i Finland år 2017 var 11 000 kg dvs. lägre än någonsin. Både försäljningen av preparat som administreras oralt och preparat som administreras i form av injektion sjönk klart. Särskilt försäljning av tabletter för sällskapsdjur visar en tydlig minskande trend under senaste åren. Andelen kritiskt viktiga antimikrobiella medel var mycket liten. Trots det minskade försäljningen av tredje generationens cefalosporiner betydligt. Majoriteten av antimikrobiella läkemedel såldes för djurindivider (65%) och penicillin var fortvarande det mest sålda antimikrobiella läkemedlet för djur. Resistenssituationen hos bakterien som har isolerats från djur och livsmedel av animalisk ursprung har hållits relativt god i Finland. Hos vissa bakterier förekomsten av resistens var ändå måttlig eller vanlig. Därför uppmärksamhet måste ägnas åt att minska behovet av att använda antimikrobiella medel för djur och kontrollerad användning av antimikrobiella medel. Det är viktigt att följa rekommendationerna för användning av antimikrobiella medel för djur. Hos campylobakter och salmonella konstaterades huvudsakligen litet resistens. Resistens mot fluorokinoloner har inte längre ökats. Bland patogener isolerade från produktionsdjur mest anmärkningsvärd ändring har skett i patogener från lunginflammation hos kalvar där resistens situation har försämrats. Annars konstaterades särskilda ändringar inte. Hos bakteriestammar som isolerats från hundar, katter och hästar minskade resistensen för så gott som alla antibiotika. För vissa läkemedel är andelen resistenta stammar trots allt fortfarande hög. Förekomsten av ESBL/AmpC bakterier var den vanligaste hos broilrar och broilerkött men de fanns väldigt litet or inte alls hos grisar, nötkreatur, svinkött eller nötkött. Förekomsten av MRSA hos slaktpartier av svin var väldig hög men de fanns relativt lite in svinkött.
Utgivningsdatum	December 2018
Referensord	Resistens mot antimikrobiella medel, användning av antimikrobiella medel
Publikationsseriens namn och nummer	Eviras publikationer 5/2018
Antal sidor	57
Språk	Engelska
Konfidentialitet	Offentlig
Förläggare	Livsmedelssäkerhetsverket Evira
Layout	Livsmedelssäkerhetsverket Evira, enheten för interna stödtjänster
	ISSN 1797-299X, ISBN 978-952-225-173-2 (pdf)

Abstract

This report presents the results obtained in the FINRES-Vet monitoring in 2016-2017. However, to better discern long-term development, the tables and figures about the consumption of antimicrobials and feed additives contain corresponding data from a longer period. The report describes the occurrence of resistance in zoonotic and indicator bacteria from food-producing animals, as well as in bacteria pathogenic to companion and food-producing animals. Furthermore, changes in the food-producing animal population, and the consumption of antimicrobials and feed additives are reviewed.

The monitoring of antimicrobial resistance in bacteria isolated from food-producing animals and meat was harmonised in the European Union in 2014 (2013/652/EU). In addition to the results obtained in the mandatory monitoring, this report includes the results of the susceptibility testing for certain animal pathogens, and the prevalence of extended-spectrum beta-lactamase producing *Escherichia coli* and MRSA in food-producing animals and meat.

Sales of veterinary antimicrobials in Finland

The overall sales of veterinary antimicrobials, in kg active ingredient, decreased by 10% from 2015 to 2017 reaching the lowest ever recorded level of antimicrobial consumption in Finland. During the same period, a continuing slow decrease in the number of dairy cattle was seen and the number of pigs decreased by 9%. When overall sales are adjusted to the number of production animals a 17% decrease from 2014 to 2016 is observed [1] (2017 results are not yet available).

A clear decrease in sales of both orally used products and injectables was seen during the observation period. Especially the sales of tablets intended for companion animals fell considerably. For oral products by class, the greatest decline was noted in the use of 1st generation cephalosporins, aminopenicillins, macrolides and the combination of trimethoprim-sulfonamide. The decreasing trend of sales of injectable penicillins continued.

The sales of the highest priority critically important antimicrobials (HPCIA) remained very low. Nevertheless, a significant decrease was noted for the sales of 3rd generation cephalosporins from 2015 to 2017. Also, the sales of macrolides and fluoroquinolones decreased.

[1] Population corrected sales in accordance of ESVAC (European surveillance of veterinary antimicrobials consumption), for details see 1.2 and 1.2.1.1.

Antimicrobial resistance in zoonotic bacteria

Salmonella findings in food-producing animals and foods of animal origin are rare in Finland. The majority of *Salmonella* isolates were susceptible to the tested antimicrobials in 2016-2017. Resistance against one or two antimicrobials occurred in five out of 54 isolates. Multiresistance (resistance to ≥3 different antimicrobial classes) was not found.

Resistance in *Campylobacter jejuni* isolates from broilers has usually been low although resistance to tetracycline and quinolones was at moderate level in 2014. Resistance to these agents was observed also in 2016 but in lower levels: 15% to nalidixic acid, 8% to ciprofloxacin and 6% to tetracycline. In 2017, resistance to the tested antimicrobials were no longer detected. In *Campylobacter coli* from pigs, resistance has mainly been detected only against quinolones throughout the 2010's. From 2010 to 2017, resistance has been decreasing and in 2017, resistance to nalidixic acid and ciprofloxacin was found in 17% of the *C. coli* isolates. In *Campylobacter jejuni* isolates from fur animals, resistance to tetracycline was common (39% in 2016 and 33% in 2017), and moderate to ciprofloxacin and nalidixic acid (both 15% in 2016 and 17 % in 2017).

ESBL/AmpC *E. coli* screening in food-producing animals and meat

The prevalence of ESBL/AmpC-producing *E. coli* was moderate in broilers (14%) and low in pigs (3%) and in cattle (1%). The majority of the isolates were AmpC-producers. In 2016, the prevalence of ESBL/AmpC-producing *E. coli* was 22% in fresh broiler meat samples of domestic origin taken at retail stores. Like in broilers, AmpC-producing *E. coli* was more commonly found in broiler meat than ESBL phenotype. From fresh beef and pork samples, ESBL/AmpC-producing *E. coli* was not found in 2017. Carbapenemase production was neither detected in food-producing animals nor meat.

Specific MRSA screening in pigs and meat

The prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) was investigated in pig slaughter batches in a year-long survey in 2016-2017. MRSA was found in 47 (77%) slaughter batches. MRSA was now more common than in a similar survey in 2009-2010.

The prevalence of MRSA was monitored from fresh pork in 2017. Of the 220 pork samples analysed, MRSA was found in 13 (6%) samples. Three different *spa* types were detected, t034, t011 and t2741, which all belong to the livestock-associated clonal complex (CC) 398.

Antimicrobial resistance in animal pathogens from food-producing animals

Isolates of animal pathogens were cultured and identified from clinical samples sent to Evira's laboratories with accredited methodology. The pathogens included are bovine respiratory pathogens, *Actinobacillus pleuropneumoniae* from swine pneumonia, *Staphylococcus aureus* from broiler tenosynovitis cases, *Escherichia coli* from porcine enteritis (confirmed to be enterotoxigenic *E. coli* by PCR) and broiler colibacillosis as well as *Brachyspira pilosicoli* from pigs. CLSI clinical breakpoints are used when available.

Antimicrobial resistance of *E. coli* bacteria from porcine enteritis has been alarming for several years. Also in 2016-2017, resistance against all orally administered antimicrobials that are in use for treatment of porcine enteritis was commonly

detected. Multidrug resistance, meaning resistance for three or more antimicrobial classes, was common. Several strains resistant to 3rd generation cephalosporins are detected annually and these isolates have had the AmpC phenotype. For these reasons, the choice of antimicrobial therapy should always be based on the resistance profiles obtained from the given farm. There are no standardised cut-off values for resistance for *Brachyspira* bacteria from swine. When clinical cut-off values used in Finland were applied to MIC distributions of *B. pilosicoli*, no resistance to valnemulin was detected, but a decreased susceptibility to tiamulin was seen (year 2017) in one isolate (4%). Resistance to tylosin (52%) and lincomycin (26%) was common in 2017. The number of farms sending faecal samples each year is relatively low in terms of the number of total pig farms in Finland. It would be crucial to include strains from several other farms in order to have more representative data of the whole Finnish pig population. *Actinobacillus pleuropneumoniae* isolates were mainly sensitive except for 4.5% tiamulin resistance in 2016.

The resistance situation in cattle respiratory pathogens is worrisome because of the increasing number of *Mannheimia haemolytica* isolates that have intermediate susceptibility against penicillin. In one calf rearing unit, oxytetracycline resistant *Histophilus somni* was detected in three sample batches. This is the first time resistance is seen in *H. somni* in Finland.

The resistance in poultry pathogens is reported from *Staphylococcus aureus* causing arthritis and tenosynovitis, and *E. coli* causing colibacillosis. The use of antimicrobials in poultry is very limited. Annually only around twenty parent flocks are treated with antimicrobials. The treatments are mostly targeted against *Staphylococcus aureus* causing tenosynovitis and the susceptibility testing is performed before the treatment is started. In 2016-2017, penicillin resistance was not detected in *S. aureus* from broilers. Since 2014, colibacillosis has been a significant problem in both parent and production flocks in Finland. Still no antimicrobial treatments are targeted against *E. coli* in poultry. Despite this, there was a low level of resistance to several tested antimicrobial substances each year. This is most likely due to the fact that resistant *E. coli* is present in the parent flocks already when they are imported.

Antimicrobial resistance in animal pathogens from companion animals

Antimicrobial resistance statistics for companion animals (dogs and cats) and horses were received from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. The data covers the time period from January 2014 to December 2017 although can be shorter in cases where data is lacking. Bacterial species included in this report were *Staphylococcus aureus* (dogs, cats and horses), *Staphylococcus pseudintermedius* (dogs), *Staphylococcus felis* (cats), *Escherichia coli* (dogs, cats and horses), *Streptococcus* spp. (dogs, cats, horses), *Enterococcus faecalis* (dogs and cats), *Pasteurella* spp. (dogs and cats), and *Actinobacillus* spp. (horses). Resistance figures have been presented by animal and bacterial species, and per year, if there were enough data, otherwise the data were collated.

S. aureus isolates from dogs, cats and horses were collated. The level of antimicrobial resistance was low, except for penicillin to which 55% of the isolates were resistant. Equine *S. aureus* isolates were less frequently penicillinase positive than isolates from dogs or cats species. Only seven MRSA isolates (contributing less than 3% of tested isolates) were observed during the whole period.

Antimicrobial resistance among *S. pseudintermedius* isolates from dogs was high for erythromycin, clindamycin and tetracycline, but a decreasing tendency was noted for 2015-2017. Oxacillin resistance (proportion of MRSP) ranged between 12-14% in 2014-2016 but then fell to 9% in 2017. Fucidic acid resistance decreased from 29 to

17% during the follow-up period. Reduction were also observed in doxycycline (from 39 to 29%) and in chloramphenicol (from 19 to 14%) as well as in enrofloxacin (from 7 to 5%) resistance levels.

Aminopenicillin resistance in canine *E. coli* isolates remained high and amoxicillin-clavulanic acid resistance moderate for the whole period although for the latter, a slight decrease (from 21 to 16%) in resistance was noted from 2016 to 2017. Sulfonamide-trimethoprim resistance varied between 12-18% being nearly 15% in 2017. Within the period of 2015-2017, enrofloxacin resistance decreased from 15 to 7%. Proportion of ESBL (extended spectrum beta-lactamase producers) *E. coli* was 2-3% in 2014-2016 and 1.6% in 2017, while the proportions for AmpC (cephalosporinase producers) were 5-6% and 3.5%, respectively. In 2015, two carbapenemase positive *E. coli* observations were recorded.

Less resistance was observed in feline *E. coli* compared to canine isolates. Highest resistance levels were recorded for ampicillin (27% in 2017) and amoxicillin-clavulanic acid (7% in 2017), but in both cases, there was clear reduction in resistance proportions compared to year 2016. Sulfonamide-trimethoprim resistance decreased from 10% (in 2015) to 3% (in 2017). The proportion of ESBL and AmpC production was very low to low in feline *E.coli*.

Proportions of resistant isolates to aminopenicillins (49% in 2016-2017) and sulfonamide-trimethoprim (42% in 2016-2017) were still high in equine *E. coli* although decreasing figures were noted for both substances compared to previous two-year period in 2014-2015. Gentamicin resistance decreased from 30 to 12%, and enrofloxacin resistance from 21 to 9% in 2016-2017 compared to 2014-2015. For the whole period there were five ESBL *E. coli* isolates corresponding 7.6% of the tested isolates (n=66).

Regarding other companion animal and equine pathogens, all streptococci included in this report were uniformly susceptible to penicillin. Resistance to sulfonamide-trimethoprim was also uncommon although increasing numbers of equine streptococci non-susceptible to this agent indicate that development of resistance should be carefully followed in the future. Macrolide-lincosamide resistance in *Streptococcus* spp. varied between 9-26% according to animal species and tested antimicrobial agent. *Pasteurella* spp. isolates from dogs and cats were all susceptible to aminopenicillins and only one canine isolate was non-susceptible to sulfonamide-trimethoprim. Also, all canine and feline *E. faecalis* isolates were susceptible to aminopenicillins. Of feline *Staphylococcus felis,* 26% manifested resistance to penicillin, but none to sulfonamide-trimethoprim or oxacillin. Decreased susceptibility to penicillin and sulfonamide-trimethoprim was moderate in equine *Actinobacillus* spp.: 21% and 13%, respectively, but the number of tested isolates was low.

Antimicrobial resistance in indicator bacteria

In this report, the results of indicator *E. coli* from slaughtered broilers and cattle in 2016, and from slaughtered pigs in 2017 are presented. Resistance against the tested antimicrobials varied from rare to moderate among *E. coli* isolates from pigs. Highest resistance levels were found against tetracycline, sulfamethoxazole and trimethoprim. Resistance levels in *E. coli* from pigs mainly decreased from 2015. In broilers, resistance among *E. coli* was low or rare against all of the examined antimicrobials; resistance to tetracycline was most common (10%). Among indicator *E. coli* from cattle, resistance was mainly rare or very low.

Tiivistelmä

Tähän raporttiin on koottu FINRES-Vet-seurannan tulokset vuosilta 2016–2017. Pitemmän aikavälin muutosten hahmottamiseksi raportin eläinlääkkeiden ja rehun lisäaineiden kulutustaulukot ja kaaviot sisältävät tietoja aiemmilta vuosilta. Raportissa tarkastellaan mikrobilääkeresistenssin esiintymistä tuotantoeläimistä eristetyissä zoonoottisissa ja indikaattoribakteereissa, sekä tuotanto-, seura- ja harraste-eläimillä tautia aiheuttavissa bakteereissa. Lisäksi raportissa esitellään Suomen eläinlääkevalmisteiden myyntitiedoissa sekä tuotantoeläinpopulaatiossa tapahtuneet muutokset.

Tuotantoeläimistä ja elintarvikkeista eristettyjen bakteerien resistenssiseuranta (2013/652/EU) yhdenmukaistettiin koko EU:ssa vuoden 2014 alussa. EU-jäsenmaissa yhteisten, pakollisten seurantakohteiden lisäksi tämä raportti sisältää tiettyjen eläinpatogeenien tuloksia, sekä laajakirjoisia beetalaktamaaseja tuottavien *Escherichia coli* -bakteerien ja MRSA-bakteerien esiintyvyystuloksia tuotantoeläimistä ja niistä saatavassa lihasta.

Eläinten mikrobilääkkeiden kulutus Suomessa

Eläinten mikrobilääkkeiden kokonaismyynti, kg vaikuttavaa ainetta, väheni 10 % Suomessa vuosina 2015–2017 ja oli matalampi kuin koskaan aikaisemmin. Samaan aikaan sikojen määrä väheni 9 % ja nautojen lukumäärän hidas lasku jatkui. Tuotantoeläinten määrään suhteutettu mikrobilääkkeiden kokonaismyynti väheni 2014 – 2016 välisenä aikana 17 %[2] (2017 tulokset saadaan vasta myöhemmin).

Sekä suun kautta annettavien että injektiovalmisteiden myynti väheni selvästi. Erityisesti seuraeläimille tarkoitettuja tabletteja myytiin aikaisempaa vähemmän. Suun kautta annettavista valmisteista eniten laski 1. polven kefalosporiinien, aminopenisilliinien, makrolidien ja sulfa-trimetopriimi-yhdistelmän myynti. Injektiopenisilliinien myynnin lasku jatkui.

Kriittisen tärkeiden mikrobilääkkeiden myynti oli erittäin vähäistä. Siitäkin huolimatta 3. polven kefalosporiinien myynti väheni huomattavasti entisestään. Myös fluorokinoloneja myytiin vielä aikaisempaa vähemmän.

Zoonooseja aiheuttavien bakteerien resistenssi

Tuotantoeläimistä eristetään vuosittain korkeintaan muutamia kymmeniä salmonelloja. Tämä kuvastaa tartuntojen kansainvälisesti vertaillen erittäin alhaista tasoa. Vuosina 2016–2017 suurin osa tutkituista salmonellakannoista oli herkkiä kaikille tutkituille mikrobilääkeaineille. Resistenssiä yhdelle tai kahdelle lääkeaineelle todettiin vain viidellä kannalla kaikista tutkituista 54 salmonellakannasta. Moniresistenssiä (resistenssiä vähintään kolmelle mikrobilääkeainaryhmälle) ei todettu.

[2] Tuotantoeläinten määrään suhteutettu myynti ESVAC-projektin (Eurooppalainen eläinten mikrobilääkkeiden myynnin seurantaprojekti) mukaisesti. Lisätietoja ks. 1.2 ja 1.2.1.1.

Broilereista eristetyillä kampylobakteereilla on esiintynyt resistenssiä pääasiassa vähän, vaikka resistenssi tetrasykliinille ja kinoloneille oli kohtalaista vuonna 2014. Tetrasykliini- ja kinoloniresistenssiä todettiin hieman vähäisemmässä määrin myös vuonna 2016: nalidiksiinihapolle 15 %, siprofloksasiinille 8 % ja tetrasykliinille 6 %. Vuonna 2017 resistenssiä näille mikrobilääkeaineille ei enää todettu. Sioista eristetyillä kampylobakteereilla resistenssiä on 2010-luvulla todettu pääasiassa kinoloneille. Vuosina 2010–2017 kinoloniresistenssi on vähentynyt ollen vuonna 2017 17 %. Turkiseläimistä eristetyillä *Campylobacter jejuni* -kannoilla resistenssi tetrasykliinille oli yleistä (39 % v. 2016 ja 33 % v. 2017) sekä siprofloksasiinille ja nalidiksiinihapolle melko yleistä (molemmille 15 % v. 2016 ja 17 % v. 2017).

Laajakirjoisia beetalaktamaaseja tuottavien *E. coli* -bakteerien seulonta tuotantoeläimistä ja niistä saatavassa lihassa

Laajakirjoisia beetalaktamaaseja (ESBL/AmpC) tuottavia *E. coli* -bakteereita esiintyi kohtalaisesti broilereilla (14 %), mutta vähän sioilla (3 %) ja naudoilla (1 %). Suurin osa eristetyistä kannoista oli AmpC-tuottajia. Vähittäismyynnissä olleessa tuoreessa, kotimaisessa broilerinlihassa ESBL/AmpC-*E. coli* -bakteerien esiintyvyys oli 22 % vuonna 2016. Kuten broilereilla, AmpC oli yleisempi löydös myös broilerinlihassa. Tuoreesta sian- tai naudanlihasta ESBL/AmpC-*E. coli* -bakteereita ei todettu lainkaan vuonna 2017. Karbapenemaasin tuottajia ei todettu tuotantoeläimissä tai lihassa.

Metisilliinille resistentti *Staphylococcus aureus* (MRSA) sioissa ja lihassa

MRSA-bakteerin esiintyvyyttä sikojen teuraserissä tutkittiin vuoden pituisessa seurannassa vuosina 2016–2017. MRSA todettiin 47 (77 %) teuraserästä ja sitä löydettiin nyt useammin kuin vastaavassa seurantatutkimuksessa vuosina 2009–2010.

MRSA-tilannetta kartoitettiin vuonna 2017 tuoreessa, maustamattomassa vähittäismyydyssä sianlihassa. Seulonnassa tutkittiin yhteensä 220 eri lihavalmiste-erää, joista kolmessatoista (6 %) todettiin MRSA-bakteeria. Todetut kannat olivat *spa*-tyyppejä t034, t011 ja t2741, jotka kuuluvat tuotantoeläimillä yleisesti todettuun CC398-ryhmään.

Tuotantoeläinten taudinaiheuttajien resistenssi

Tutkitut kannat on eristetty ja tunnistettu Eviran eläintautidiagnostiikkaa tekevissä laboratorioissa tuotantoeläinten kliinisistä näytteistä akkreditoiduilla menetelmillä. Raportti sisältää resistenssituloksia nautojen ja sikojen hengitystietulehduksia aiheuttavista bakteereista, broilerien jännetuppitulehduksista aiheuttavista *Staphylococcus aureus* -bakteereista, broilerien kolibasilloosia ja porsaiden suolistotulehdusta aiheuttavista *Escherichia coli* -bakteereista (varmistettu suolistotulehduksen aiheuttajaksi PCR-tutkimuksella) sekä sikojen suolistotulehdusta aiheuttavista *Brahyspira pilosicoli* -bakteereista. Tulkinnassa on käytetty CLSI:n kliinisiä raja-arvoja siltä osin kuin ne ovat saatavilla.

Porsaiden suolistotulehdusta aiheuttavien *E. coli* -bakteerien resistenssitilanne on ollut jo vuosia huolestuttava ja myös vuosina 2016 ja 2017 resistenssiä todettiin yleisesti kaikille sioille käytössä oleville suun kautta annettaville mikrobilääkkeille. Moniresistenssi, eli resistenssi kolmelle tai useammalle mikrobilääkeryhmälle, on näissä kannoissa tavallista. Vuosittain todetaan joitakin kolmannen polven kefalosporiineille resistenttejä kantoja, joilla kaikilla on AmpC-fenotyyppi. Näistä syistä suolistotulehdusta hoidettaessa lääkitysvalinta tulisi tehdä nimenomaan kyseiseltä tilalta eristettyjen kantojen herkkyysmäärityksen perusteella. Sikojen *Brachyspira*-bakteereille ei ole olemassa standardisoituja hyväksyttyjä raja-arvoja. Suomessa käytettyjen kliinisten raja-arvojen perusteella valnemuliinille ei todettu resistenssiä, mutta vuonna 2017 todettiin yhdellä kannalla alentunut herkkyys

tiamuliinille (4 %). Resistenssi tylosiinille (52 %) ja linkomysiinille (26 %) oli yleistä vuonna 2017. Sikojen ulostenäytteitä lähettävien tilojen lukumäärä on melko pieni Suomen sikatilojen määrään nähden, joten olisi tärkeää saada näytteitä useammilta tiloilta, jotta tulokset edustaisivat paremmin koko Suomen sikapopulaatiota. *Actinobacillus pleuropneumoniae* -kannat olivat herkkiä lukuun ottamatta vuonna 2016 todettua 4,5 % resistenssiä tiamuliinille.

Nautojen hengitystiepatogeenien resistenssitilanne on huolestuttava *Mannheimia haemolytica* -bakteerin osalta. Kantojen jakaumassa on nähtävissä uhkaava penisilliiniresistenssin lisääntyminen. Yhdessä vasikkakasvattamossa todettiin 2017 kolmessa eri näytelähetyksessä tetrasykliinille resistentti *Histophilus somni*. Tämä on ensimmäinen kerta, kun resistenssiä todetaan tässä bakteerilajissa Suomessa.

Siipikarjan osalta resistenssiä seurataan nivel- ja jännetuppitulehduksia aiheuttavien *Staphylococcus aureus* -bakteerien sekä kolibasilloosiksi kutsuttua yleistulehdusta aiheuttavien *E. coli* -bakteerien osalta. Siipikarjalla mikrobilääkkeiden käyttö on hyvin vähäistä. Vuosittain lääkitään vain parisenkymmentä emobroileriparvea. Yleisin lääkityksen syy on *S. aureus* -bakteerien aiheuttama nivel- ja jännetuppitulehdus, ja näille bakteereille tehdään herkkyysmääritys ennen lääkityksen aloittamista. Vuosina 2016–2017 kannoilla ei todettu penisilliiniresistenssiä. Kolibasilloosi on ollut vuodesta 2014 lähtien merkittävä ongelma emo- ja tuotantoparvissa, mutta parvia ei lääkitä sen vuoksi. Silti bakteerikannoissa todetaan jonkin verran alentunutta herkkyyttä monille mikrobilääkkeille. Tämä alentunut herkkyys johtunee siitä, että maahantuoduissa emountuvikoissa on jo valmiiksi *E. coli* -bakteereita, joissa resistenssiä esiintyy.

Seuraeläinten (koirien, kissojen ja hevosten) taudinaiheuttajien resistenssi

Harraste- ja seuraeläinten osalta aineisto koottiin eläinlääketieteellisen tiedekunnan kliinisen mikrobiologian laboratoriosta Helsingin yliopistossa vuosina 2014–2017. Raportti sisältää resistenssitiedot seuraavista bakteereista: *S. aureus* (koirat, kissat, hevoset), *S. pseudintermedius* (koirat), *S. felis* (kissat), *E. coli* (koirat, kissat, hevoset), *Streptococcus* spp. (koirat, kissat, hevoset), *E. faecalis* (koirat ja kissat), *Pasteurella* spp. (koirat ja kissat) ja *Actinobacillus* spp. (hevoset). Resistenssi-prosentit on esitetty eläin- ja bakteerilajeittain, sekä vuosittain, mikäli taustadatan määrä on ollut riittävä. Muussa tapauksessa tietoa on niputettu yhteen.

Koirien, kissojen ja hevosten *S. aureus* -löydöksissä resistenssi oli vähäistä lukuun ottamatta penisilliiniresistenssiä, sillä 55 % kannoista tuotti beetalaktamaasia. Hevosten *S. aureus* -kannat tuottivat harvemmin penisillinaasia kuin koirien tai kissojen infektioista eristetyt kannat. Koko seuranta-aikana raportoitiin vain seitsemän MRSA-löydöstä (alle 3 % testatuista kannoista).

S. pseudintermedius -bakteereissa resistenssi oli korkea erytromysiinille, klindamysiinille ja tetrasykliinille, mutta laskusuunnassa vuosina 2015–2017. MRSP-bakteerin osuus vaihteli 12–14 % välillä vuosina 2014–2016, mutta väheni 9 %:iin vuonna 2017. Fusidiinihapporesistenssi laski 29 %:sta 17 %:iin seurantajakson aikana. Resistenssi väheni myös doksisykliinille, kloramfenikolille, ja enrofloksasiinille.

Aminopenisilliinille resistenttien kantojen osuus koirien *E. coli* -löydöksissä pysyi korkealla ja amoksisilliini-klavulaanihapolle kohtalaisen korkeana koko seurantajakson ajan, vaikkakin jälkimmäisen kohdalla osuus laski 21 %:sta 16 %:iin 2016–2017. Sulfonamidi-trimetopriimille resistenssi vaihteli 12 ja 18 % välillä ollen 15 % vuonna 2017. Enrofloksasiiniresistenssi laski vuosina 2015–2017 15 %:sta 7 %:iin. Laajakirjoisia beetalaktamaaseja tuottavien ESBL-kantojen osuus oli 2-3 % vuosina 2014–2016 ja 1,6 % vuonna 2017, kun taas kefalosporinaaseja tuottavien AmpC-kantojen

osuus samalla ajanjaksolla oli 5-6 % ja 3,5 % vuonna 2017. Vuonna 2015 löydettiin kaksi karbapenemaasia tuottavaa NDM-*E. coli* -kantaa.

Kissoista eristetyt *E. coli* -löydökset olivat herkempiä kuin koirien *E. coli* -bakteerit. Vuonna 2017 ampisilliinille resistenttejä kantoja oli 27 % ja amoksisillini-klavulaani-hapolle resistenttejä 7 %. Molempien lääkeaineiden osalta resistenssiluvut laskivat selvästi vuoteen 2016 verrattuna. Myös sulfonamidi-trimetopriimiresistenssi väheni ja oli enää 3 % vuonna 2017. ESBL kantojen osuus kissojen *E. coli* -bakteereissa oli matala ja AmpC-kantojen osuus hyvin matala.

Hevosten *E. coli* -bakteereissa aminopenisilliiniresistenssi (49 % vuosina 2016–2017) ja sulfonamidi-trimetopriimiresistenssi (42 % vuosina 2016–2017) oli edelleen korkea, vaikkakin laskussa verrattuna vuosiin 2014–2015. Gentamisiiniresistenssi väheni seurantajaksolla 30 %:sta 12 %:iin ja enrofloksasiiniresistenssi 21 %:sta 9 %:iin. Koko aikana rekisteröitiin viisi ESBL-*E. coli* -kantaa, joka on 7.6 % testatuista kannoista (n=66).

Muiden patogeenien osalta resistenssitilanne oli hyvä: esimerkiksi streptokokit olivat kaikki penisilliinille herkkiä ja vain yksittäiset koirien ja kissojen streptokokit olivat resistenttejä sulfonamidi-trimetopriimille. Hevosten osalta tilannetta tulee seurata, sillä sulfonamidi-trimetopriimille resistenttien *Streptococcus equi ssp. zooepidemicus* -kantojen määrä oli noususuuntainen. Makrolidi-linkosamidiresistenssi vaihteli 9-26 % välillä riippuen eläinlajista ja testatusta lääkeaineesta. Kaikki koirien ja kissojen *Pasteurella* spp. -löydökset olivat herkkiä aminopenisilliineille, ja kaikki paitsi yksi sulfonamidi-trimetopriimille. Aminopenisilliiniresistenssiä ei tavattu myöskään koirien ja kissojen *E. faecalis* -bakteereissa. Kissojen *S. felis* -löydöksistä 26 % oli penisilliinille resistenttejä, mutta metisillliinille (oksasilliini) tai sulfonamidi-trimetopriimille ei todettu resistenssiä.

Indikaattoribakteerien resistenssi

E. coli -indikaattoribakteereita kerättiin vuonna 2016 broilereista ja naudoista sekä vuonna 2017 sioista teurastuksen yhteydessä otetuista näytteistä. Sioista eristetyillä *E. coli* -kannoilla resistenssi vaihteli harvinaisesta kohtalaiseen. Eniten resistenssiä esiintyi tetrasykliinille, sulfametoksatsolille ja trimetopriimille. Resistenssi sioista eristetyillä *E. coli* -bakteereilla oli pääasiassa vähäisempää kuin 2015. Broilereista eristetyillä *E. coli* -kannoilla resistenssiä esiintyi yleisesti ottaen hyvin vähän, resistenssiä tetrasykliinille todettiin eniten (10 %). Naudoista eristetyillä *E. coli* -indikaattoribakteereilla resistenssiä todettiin suurimmalla osalle mikrobilääkeaineista hyvin vähän tai ei lainkaan.

Resumé

Denna rapport sammanfattar resultaten från resistensuppföljningsprogrammet FINRES-Vet åren 2016–2017. För att ge en bild av förändringarna på längre sikt, ingår uppgifter om konsumtionen av veterinärmedicinska läkemedel och fodertillsatser under tidigare år i rapportens tabeller och scheman. I rapporten granskas förekomsten av antibiotikaresistens hos zoonotiska bakterier och indikatorbakterier som isolerats från produktionsdjur, och bakterier som orsakar sjukdom hos produktionsdjur, sällskapsdjur och hobbydjur. I rapporten presenteras också förändringar vad gäller uppgifterna om försäljning av veterinärmedicinska läkemedel och produktionsdjurpopulationen i Finland.

Uppföljningen av resistensen hos bakterier som isolerats från livsmedelsproducerande djur och livsmedel harmoniserades i hela EU i början av år 2014 (2013/652/EU). Utöver de obligatoriska uppföljningsobjekten som är gemensamma för EU-medlemsstaterna ingår i denna rapport resultaten om vissa djurpatogener samt förekomsten av *Escherichia coli* -bakterier som producerar betalaktamaser med utvidgat spektrum och MRSA-bakterier hos livsmedelproducerande djur och i köttet från dessa djur.

Konsumtion av antimikrobiella läkemedel för djur i Finland

Den totala försäljningen av antimikrobiella medel för djur i Finland minskade med 10 % åren 2015-2017 och var lägre än någonsin. Samtidigt minskade antalet svin med 9 % och den långsamma nedgången i antalet nötkreatur fortsatte. Den totala försäljningen av antimikrobiella medel i relation till antalet produktionsdjur har minskat med 17 % sedan år 2014 och var 19 mg/PCU år 2016[3] (uppgifterna för år 2017 är ännu inte tillgängliga).

Både försäljningen av preparat som administreras oralt och preparat som administreras i form av injektion sjönk klart. Specielt tabletter för sällskapsdjur såldes i lägre grad än tidigare. Av de preparat som administreras oralt sjönk mest försäljningen av första generationens cefalosporiner, aminopenicilliner, makrolider och kombinationen sulfa-trimetoprim. Nedgången i försäljningen av penicilliner som ges som injektion fortsatte.

Andelen kritiskt viktiga antimikrobiella medel var mycket liten. Trots det minskade försäljningen av tredje generationens cefalosporiner betydligt jämfört med tidigare år. Även försäljningen av fluorokinoloner minskade ytterligare.

Resistensen hos bakterier som orsakar zoonoser

Salmonella bakterier konstateras i livsmedelsproducerande djur årligen i högst några tiotal fall. Detta reflekterar en mycket låg nivå av infektioner i internationell jämförelse.

[3] Försäljning i proportion till mängden viktigaste produktionsdjurarter enlingt ESVAC (European surveillance of veterinary antimicrobials consumption), för detaljer se 1.2 och 1.2.1.1.

Åren 2016–2017 var största delen av de undersökta salmonellastammarna känsliga för alla undersökta antimikrobiella medel. Resistens mot ett eller två läkemedel påvisades endast hos fem stammar av alla 54 salmonellastammar som undersöktes. Multiresistens (resistens mot minst tre grupper antimikrobiella medel) påvisades inte.

Hos campylobacter som isolerats från broilrar har huvudsakligen förekommit endast föga resistens, även om resistensen mot tetracyklin och kinoloner var måttlig år 2014. Resistens mot tetracyklin och kinoloner påvisades i något mindre utsträckning även år 2016: 15 % resistens mot nalidixinsyra, 8 % mot ciprofloxacin och 6 % mot tetracyklin. År 2017 påvisades inte resistens mot dessa antimikrobiella medel. Hos campylobacter som isolerats från svin har resistens främst påvisats mot kinoloner på 2010-talet. Kinolonresistensen har minskat under åren 2010–2017 och var 17 % år 2017. Hos stammar av *Campylobacter jejuni* som isolerats från pälsdjur var resistens mot tetracyklin allmän (39 % år 2016 och 33 % år 2017), och rätt allmän mot ciprofloxacin och nalidixinsyra (15 % för båda år 2016 och 17 % år 2017).

Screening av *E. coli* som producerar betalaktamaser med utvidgat spektrum hos livsmedelsproducerande djur och i kött som erhålls från sådana

Förekomsten av *E. coli* -bakterier som producerar betalaktamaser med utvidgat spektrum (ESBL/AmpC) var måttlig hos broilrar (14 %), men låg hos svin (3 %) och nötkreatur (1 %). Största delen av de isolerade stammarna var AmpC-producenter. Förekomsten av ESBL/AmpC-*E coli* i färskt inhemskt broilerkött i detaljhandeln var 22 % år 2016. AmpC påvisades oftare i broilerkött, liksom även hos broilrar. Inga ESBL/AmpC-E *coli* bakterier påvisades i färskt svin- och nötkött år 2017. Produktion av karbapenemas påvisades inte, varken hos livsmedelsproducerande djur eller i kött.

Meticillinresistent *Staphylococcus aureus* (MRSA) i svin och kött

Förekomst av MRSA-bakterier i slaktpartier av svin analyserades i en ettåring uppföljning 2016-2017. MRSA påvisades i 47 slaktpartier (77 %), och påvisades nu oftare än i motsvarande uppföljningsundersökning 2009-2010.

År 2017 utreddes förekomsten av MRSA i färskt griskött som hade samlats in i detaljhandelsledet. Totalt 220 prover av griskött undersöktes och i tretton (6 %) av proverna konstaterades MRSA. MRSA-stammarna var av *spa* typerna t034, t011 och t2741, som hör till den hos livsmedelsproducerande djur allmänt konstaterade CC398-kategorin.

Resistensen hos bakterier som orsakar sjukdomar hos livsmedelsproducerande djur

De analyserade stammarna har isolerats och identifierats i Eviras laboratorier som utför diagnostik av djursjukdomar utifrån kliniska prover av livsmedelproducerande djur med ackrediterade metoder. I rapporten ingår resistensresultaten för bakterier som orsakar luftvägsinfektioner hos nötkreatur och svin, *Staphylococcus aureus* -bakterier som orsakar inflammationer i senskidan hos broilerkycklingar, *Escherichia coli* -bakterier som orsakar kolibacillos hos broilrar och tarminfektioner hos svin (har verifierats genom PCR-analys) samt tarminfektioner hos svin som orsakats av bakterien *Brachyspira pilosicoli*. Vid tolkningen har använts kliniska gränsvärden fastställda av CLSI då de varit tillgängliga.

Resistens hos *E. coli* -bakterier som orsakar tarminfektioner hos grisar har varit oroande i flera år, och även åren 2016 och 2017 påvisades allmänt resistens mot alla antimikrobiella medel som ges oralt till svin. Multiresistens, dvs. resistens mot tre eller flera grupper antimikrobiella medel var allmän hos dessa stammar. Varje år påvisas

några stammar som är resistenta mot tredje generationens cefalosporiner som alla har fenotypen AmpC. Av dessa skäl borde valet av läkemedel mot tarminfektion göras utgående från resistensbestämning av stammar som isolerats på gården ifråga. Det finns inga standardiserade godkända gränsvärden för *Brachyspira*-bakterier hos svin. Utgående från de kliniska gränsvärden som används i Finland påvisades inte resistens mot valnemulin, men år 2017 påvisades nedsatt känslighet mot tiamulin hos en stam (4 %). Resistens mot tylosin (52 %) och linkomycin (26 %) var allmän år 2017. Jämfört med antalet svinstall i Finland är antalet gårdar som sänder in träckprover rätt lågt. Det skulle vara viktigt att få in prover från fler gårdar så att resultaten bättre skulle representera hela svinpopulationen i Finland. Stammarna av *Actinobacillus pleuropneumoniae* var känsliga, med undantag för 4,5 % resistens mot tiamulin som påvisades år 2016.

Resistensen mot luftvägspatogener är bekymrade då det gäller *Mannheimia haemolytica* hos nötkreatur. Fördelningen av stammarna tyder på ett ökat hot mot penicillinresistens. På en gård med kalvuppfödning påvisades tetracyklinresistenta *Histophilus somni* i tre olika provsändningar år 2017. Det är första gången som resistens har påvisats hos denna bakterieart i Finland.

Hos fjäderfä uppföljs resistens hos *Staphylococcus aureus* som orsakar ledinflammation och senskidinflammation samt en allmän infektion som kallas kolibacillos som orsakas av *E. coli* -bakterier. Antimikrobiella medel används mycket litet till behandling av fjäderfä. Årligen medicineras endast ett tjugotal avelsbroilerflockar. Den vanligaste orsaken till medicinsk behandling är ledinflammation och senskidinflammation som orsakas av *S. aureus*, och en resistensbestämning görs för dessa bakterier innan medicineringen inleds. Resistensen mot penicillin påvisades inte hos *S. aureus* -stammarna åren 2016-2017. Kolibacillos har varit ett betydande problem i avels- och produktionsflockar sedan år 2014, men flockarna medicineras inte mot det. Hos stammarna konstateras ändå en något sänkt känslighet mot flera antimikrobiella medel. Detta beror antagligen på att det finns *E. coli* -bakterier där resistens förekommer i importerade avelskycklingar.

Resistens hos bakterier som orsakar sjukdomar hos hundar, katter och hästar

Data om resistens hos hobby- och sällskapsdjur insamlades från veterinärmedicinska fakultetens laboratorium för klinisk mikrobiologi vid Helsingfors universitet under åren 2014–2017. I rapporten ingår resistensinformation beträffande följande bakterier: *S. aureus* (hundar, katter, hästar), *S. pseudintermedius* (hundar), *S. felis* (katter), *E. coli* (hundar, katter, hästar), *Streptococcus* spp. (hundar, katter, hästar), *E. faecalis* (hundar, katter), *Pasteurella* spp. (hundar, katter), och *Actinobacillus* spp. (hästar). Andelen resistenta stammar är presenterade på basen av djur- och bakterieart per år ifall tillräcklig data fanns. I annat fall buntades data ihop.

Antibiotikaresistensen hos *S. aureus* -stammar från hundar, katter och hästar var blygsam, med undantag av penicillinresistens, då 55 % av stammarna producerade betalaktamas. *S. aureus* -stammar från hästar producerade penicillinas mer sällan än stammar som isolerats från infektioner hos hundar och katter. Endast sju MRSA-fynd gjordes under hela uppföljningsperioden (under 3 % av undersökta stammarna).

Hos *S. pseudintermedius* -bakterier var resistensen hög för erytromycin, klindamycin och tetracyklin, men minskade under åren 2015–2017. Andelen MRSP-bakterier varierade mellan 12–14 % under åren 2014–2016, men minskade till 9 % år 2017. Resistens mot fusidinsyra minskade från 29 % till 17 % under uppföljningsperioden. Även förekomsten av resistens mot doxycyklin, kloramfenikol och enrofloxacin minskade.

Andelen aminopenicillinresistenta stammar utav hundars *E. coli* -bakterier förblev hög och resistensen mot amoxicillin-klavulansyra relativt hög under hela uppföljningsperioden, även om andelen minskade från 21 % till 16 % för den senare under 2016–2017. Resistens mot sulfonamid-trimetoprim varierade mellan 12 - 18 % och var 15 % år 2017. Enrofloxacinresistensen minskade under åren 2015–2017 från 15 % till 7 %. Andelen stammar som producerade betalaktamaser med brett spektrum (ESBL-stammar) var 2-3 % under åren 2014–2016 och 1,6 % år 2017, samtidigt som andelen cefalosporinas-producerande stammar (AmpC-stammar) var 5-6 % under samma tidsperiod och 3,5 % år 2017. År 2015 hittades två karbapenemasproducerande NDM-*E. coli* -stammar.

E. coli fynden från katter var mer känsliga än hundarnas *E. coli* -bakterier. År 2017 var 27 % av stammarna resistenta mor ampicillin och 7 % resistenta mot amoxicillin-klavulansyra. Bägge läkemedlens resistenssiffror minskade klart jämfört med år 2016. Även resistens mot sulfonamid-trimetoprim minskade och var endast 3 % år 2017. Andelen ESBL-stammar hos *E. coli* -bakterier från katter var låg och andelen AmpC-stammar mycket låg.

Utav hästarnas *E. coli* -bakterier var resistensen mot aminopenicillin (49 % under åren 2016–2017) och sulfa-trimetoprim (42 % under åren 2016–2017) fortfarande hög, även om andelen hade minskat jämfört med åren 2014–2015. Gentamicinresistensen minskade under uppföljningsperioden från 30 % till 12 %, medan enrofloxacinresistensen minskade från 21 % till 9 %. Under hela perioden hittades fem ESBL-*E. coli* -stammar, vilket är 7,6 % av de undersökta stammarna (n=66).

Angående andra patogener var resistenssituationen god: t.ex. var alla streptokocker känsliga för penicillin och endast enstaka streptokocker från hundar och katter var resistenta mot sulfonamid-trimetoprim. Läget för hästar bör följas, då andelen sulfonamid-trimetoprimresistenta *Streptococcus equi* ssp. *zooepidemicus* -stammar höll på att öka. Resistens mot makrolider och linkosamider varierade mellan 9 - 26 %, beroende på djurarten och det undersökta läkemedlet. Alla *Pasteurella* spp. -fynd från hundar och katter var sensitiva för aminopenicilliner och alla utom en stam även för sulfonamid-trimetoprim. Resistens mot aminopenicillin påträffades inte heller hos *E. faecalis* -bakterier från hundar och katter. Utav katters *S. felis* -fynd var 26 % resistenta mot penicillin, men resistens för meticillin (oxacillin) eller sulfonamid-trimetoprim påvisades inte.

Resistensen hos indikatorbakterier

Stammar av *E. coli* insamlades år 2016 från broilrar och nötkreatur och år 2017 från svin av prover som tagits i samband med slakt. Hos stammar av *E. coli* som isolerats från svin varierade resistensen från sällsynt till måttlig. Mest resistens förekom mot tetracyklin, sulfametoxazol och trimetoprim. Resistensen mot *E. coli* som isolerats från svin var I huvudsak lägre än år 2015. Hos stammar av *E. coli* som isolerats från broilrar förekom allmänt taget mycket litet resistens. Mest resistens påvisades mot tetracyklin (10 %). Hos indikatorbakterier av typen *E. coli* som isolerats från nötkreatur påvisades mycket litet eller ingen resistens mot de flesta antimikrobiella medel.

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Introduction

Antimicrobial resistance in bacteria isolated from animals in Finland has been studied already in the 1980's when the strains gathered from the domestic food-producing animals within the national salmonella control programme were also tested for resistance. The regular and yearly antimicrobial resistance monitoring programme, FINRES-Vet, was started in 2002 and it has included the resistance surveillance of zoonotic and indicator bacteria as well as of certain animal pathogens. Currently in the programme, resistance is monitored as required by the Commission Implementing Decision 2013/652/EU and as decided at the national level.

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

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

FINRES-Vet programme has the following objectives:

- to monitor the consumption of antimicrobial agents used to treat animals,
- to monitor the resistance to antimicrobial agents in bacteria from the major food-producing animals and pets,
- to analyse trends in resistance prevalence, and to monitor the emergence of resistant clones and the appearance of new resistance phenotypes.

The previous FINRES-Vet reports have presented an overall favourable resistance situation among bacteria isolated from animals and food of animal origin in Finland. This is probably the positive outcome of the strict policy; antimicrobial drugs for treating animals are prescribed only by veterinarians and no profit can be made from their sales. However, the resistance in some animal pathogens is of growing concern indicating that there is a need to further emphasise the preventive measures and prudent use of antimicrobials. Recommendations for antimicrobial usage in major infectious diseases of animals have been established to promote prudent use. These recommendations have been updated in 2016 and can be found in the internet site of Finnish Food Safety Authority Evira (evira.fi) (from 1.1.2019 Finnish Food Authority, ruokavirasto.fi).

This seventh FINRES-Vet report includes data from the years 2016-2017. The report covers resistance results of indicator bacteria (non-pathogenic *E. coli*), zoonotic

bacteria (salmonella and campylobacter), and several animal pathogens from the main food-producing animal species (pigs, cattle, poultry), companion animals (dogs, cats) and horses. In addition, the results of the specific monitoring of extended-spectrum beta-lactamase producing *E. coli* and MRSA are included.

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

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

1.1 Changes in animal population

Changes in the number of food-producing animals during 2016-2017 were relatively small. The decreasing trend in number of cattle has continued, but the number of suckler cows shows a little increase. The total number of pigs decreased about 9% from 2015 to 2017. The number of poultry showed a slow increase. Details on the number of holdings, live animals, and meat and milk production, are presented in Appendix 1.

1.2 Therapeutic antimicrobials

The sales of veterinary antimicrobials have been monitored in Finland since 1995. The statistics are based on sales data that is obtained at package level from the pharmaceutical wholesalers. In addition, information includes small amounts of antimicrobials that are imported as medicated feed. These data on volume are collected from feed importers. The sales statistics are expressed as weight (kg active ingredient). It is assumed that the antimicrobials obtained during the observation period are also used during that period. For details on data sources and inclusion criteria see Appendix 2.

Majority of the veterinary medicinal products are used to treat several animal species. As the statistics are based on number of packages sold it is not possible to obtain species specific data. However, the information available can be broken down by the route of administration. Another issue to consider is that the amount of medicine required to achieve the desired therapeutic effect varies between different classes of antimicrobials, i.e. the efficacy of medicines expressed per unit of active ingredient varies. It is thus important that sales, expressed in kg, are foremost compared to sales of the same class over a longer time.

The amounts of veterinary antimicrobial agents sold are linked, among others, to the animal demographics. The population correction unit (PCU) has been established as a denominator for the sales data within the ESVAC project (European Surveillance of Veterinary Antimicrobial Consumption, EMA 2011, 2018). Population adjusted sales are reported as mg active ingredient sold per population correction unit (PCU). One PCU equals approximately to one kg of biomass of food producing animals. Tablets are used almost solely for companion animals thus they are excluded from the overall sales before population correction is applied. It should be noted that PCU is purely a surrogate for the food producing animal population at risk of being treated with antimicrobials. Detailed information how PCU is calculated are described in Appendix 2 of the first ESVAC report (EMA 2011).

1.2.1 Overall sales of veterinary antimicrobial agents

The overall sales (in kg) decreased by 10% compared to 2015 and were 11 000 kg in 2017 thus being the lowest ever recorded antimicrobial consumption in Finland (Table 1, Figure 1). As earlier, the three most sold antimicrobial classes were penicillins (47%), tetracyclines (21%) and the combination of sulfonamides and trimethoprim (20%). Of individual antimicrobials, penicillin G was by far the most sold antimicrobial with 36% of the overall sales in 2017.

Table 1. Overall sales of veterinary antimicrobials in Finland 2001, 2005, and 2010-2017, kg active substance.

Overall sales[1]	2001	2005		2010	2011	2012	2013	2014	2015	2016	2017
Tetracyclines, doxycyclin	1937	1445		1728	1838	1759	2389	2576	2250	2010	2268
Amphenicols[2]				59	124	61	121	84	80	87	104
Betalactams (penicillins)				6593	6406	6223	6116	5967	5896	5274	5223
Penicillin G[1]	*6235*	*6803*		*5162*	*5010*	*4784*	*4721*	*4502*	*4332*	*3773*	*4018*
Aminopenicillins	*532*	*958*		*1317*	*1284*	*1342*	*1314*	*1374*	*1498*	*1438*	*1160*
Cloxacillin	*149*	*132*		*114*	*112*	*97*	*82*	*91*	*65*	*63*	*45*
Cephalosporins	1153	1000		911	1064	917	802	760	613	516	355
1st gen. cephalosporins				*906*	*1056*	*902*	*793*	*753*	*605*	*513*	*355*
3rd gen. cephalosporins				*5*	*9*	*15*	*8*	*8*	*7*	*3*	*1*
Sulfonamides and trimethoprim	2490	2438		3274	3045	3149	3129	2893	2445	2460	2208
Sulfonamides				*2728*	*2537*	*2624*	*2607*	*2410*	*2037*	*2049*	*1839*
Trimethoprim				*546*	*508*	*525*	*522*	*483*	*408*	*411*	*368*
Macrolides and lincosamides	492	393		774	696	755	611	711	760	636	705
Macrolides				*572*	*532*	*575*	*456*	*521*	*596*	*517*	*408*
Lincosamides				*202*	*164*	*179*	*155*	*189*	*165*	*120*	*297*
Aminoglycosides	632	238		166	128	108	103	101	93	87	73
Quinolones				96	102	107	105	113	94	99	80
Fluoroquinolones	*101*	*90*		*96*	*102*	*107*	*105*	*113*	*94*	*99*	*80*
Other Quinolones (Oxolinic acid)				*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Polymyxins[2]				0	0	0	0	0	0	0	0
Pleuromutilins[2]				48	73	66	43	44	30	23	14
Others[2]	103	112		-	-	-	-	-	-	-	-
Total	**13824**	**13609**		**13651**	**13475**	**13144**	**13419**	**13250**	**12262**	**11192**	**11029**

ESVAC harmonised sales since 2010

[1] ESVAC harmonised expression of sales since 2010 (European Surveillance of Veterinary Antimicrobial Consumption). Affects mainly penicillins.
[2] Before 2009 amphenicols, polymyxins and pleuromutilins were included in 'Others'

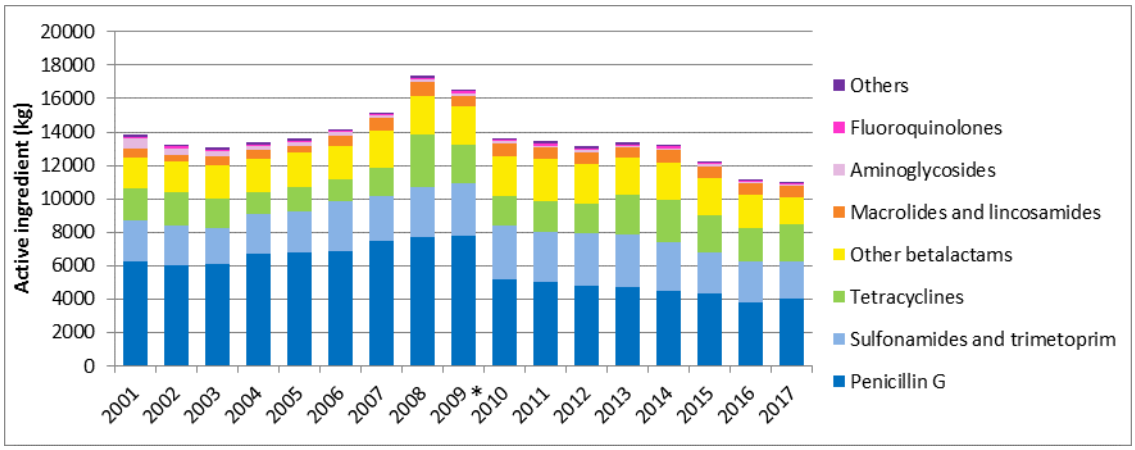

Figure 1. Overall sales of veterinary antimicrobials (kg active ingredient). *ESVAC harmonised since 2010. Other betalactams: aminopenicillins, cephalosporins and cloxacillin. Others: amphemicols, pleuromutilins and polymyxins.

1.2.1.1 Sales in relation to the production animal population

Population corrected sales for food-producing animals in Finland were stable during 2011-2014 (approximately 22 mg/PCU/year) but have since decreased by 17% to 19 mg/PCU in 2016 (EMA/ESVAC 2018).

1.2.2 Injectable antimicrobial products

The sales of injectable antimicrobials have decreased through this decade but from 2016 to 2017 a small increase was noted. The major explanation behind the changes are shifts in sales of penicillin G. It maintained the position as the most selling antimicrobial though its proportion of all injectables decreased from 78% to 72% in 2010's. Tetracyclines were the second most used injectables with a proportion of 13% of all injectables, and aminopenicillins the third (6%) in 2017.

Shortage of certified starting material caused major disturbances in the availability of injectable benzylpenicillin products in 2015-2016 which partially explains the decrease in penicillin G sales in 2016. The sales of other old antimicrobials recommended to replace benzylpenicillin during the shortage period showed variable changes, which could partly be due to temporary shortages of these products as well. Only the sales of tetracyclines increased over time. On the contrary, from 2015 a decreasing trend is seen for aminopenicillins, and the combination of trimethoprim and sulfonamide.

Details on the sales of injectable, the highest priority critically important antimicrobials are in section 1.2.5.

Table 2. Sales of injectable veterinary antimicrobials in Finland 2001, 2005, and 2010-2017, kg active substance.

Injectables[1]	2001	2005		2010	2011	2012	2013	2014	2015	2016	2017
Tetracyclines, doxycyclin	196	312	ESVAC harmonised sales since 2010	527	515	521	558	552	640	686	671
Amphenicols	0	0		0	12	13	26	17	6	13	26
Betalactams (penicillins)				5462	5253	4986	4920	4659	4520	3903	4115
Penicillin G[1]	*5981*	*6597*		*5023*	*4849*	*4552*	*4542*	*4243*	*4047*	*3450*	*3777*
Aminopenicillins	*76*	*236*		*440*	*404*	*434*	*379*	*416*	*473*	*453*	*338*
Cephalosporins[2]				5	9	15	9	8	7	8	2
1st gen. cephalosporins				*0*	*0*	*0*	*0*	*0*	*0*	*5*	*1*
3rd gen. cephalosporins				*5*	*9*	*15*	*8*	*8*	*7*	*3*	*1*
Sulfonamides and trimethoprim	599	463		329	297	360	344	358	373	322	317
Sulfonamides				*274*	*248*	*300*	*287*	*298*	*311*	*269*	*264*
Trimethoprim				*55*	*50*	*60*	*57*	*60*	*62*	*54*	*53*
Macrolides, lincosamides	63	76		52	42	37	37	37	40	44	33
Macrolides				*13*	*13*	*11*	*12*	*12*	*15*	*19*	*13*
Lincosamides				*40*	*30*	*27*	*24*	*26*	*26*	*25*	*19*
Aminoglycosides	0	11		19	18	20	12	15	13	14	12
Quinolones				78	85	84	83	90	72	78	63
Fluoroquinolones	*70*	*77*		*78*	*85*	*84*	*83*	*90*	*72*	*78*	*63*
Other Quinolones (Oxolinic acid)				*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Others	1	0		0	0	0	0	0	0	0	0
Total	**6986**	**7771**		**6472**	**6230**	**6036**	**5990**	**5737**	**5672**	**5069**	**5238**

[1] ESVAC harmonised expression of sales since 2010 (European Surveillance of Veterinary Antimicrobial Consumption)
[2] Before 2006 sales of cephalosporins was included in "Others"

1.2.3 Orally administered antimicrobial products

The sales of almost all antimicrobial classes available as oral products decreased in 2015-2017. Trimethoprim and sulfonamide combinations remained as the most sold oral antimicrobials (34% in 2017) followed by tetracyclines (29%) and aminopenicillins (16%). The sales of first generation cephalosporins and aminopenicillins decreased the most; 42% and 20%, respectively. This was mainly

due to the decreased sales of tablets for companion animals. Noteworthy is also the decrease in sales of oral fluoroquinolones that are only used in companion animals in Finland (-24%).

The sales of macrolides decreased by 30% and the sales of trimethoprim and sulfonamide combination by 9%. An exception to the descending trend was lincosamides that doubled their sales since 2015 (Table 3, Figure 2).

1.2.3.1 For group treatment

The sales of products (Figure 3) for group treatment decreased by 10% from 2015 to 2016 and remained at 3 800 kg in 2017. The decrease was mainly due to the decreased sales of macrolides and trimethoprim-sulfonamide combination.

Table 3. Sales of veterinary antimicrobials for oral administration in Finland 2001, 2005 and 2010-2017, kg active substance.

Orally administered[1]	2001	2005		2010	2011	2012	2013	2014	2015	2016	2017
Tetracyclines, doxycyclin	1672	1135	ESVAC harmonised sales since 2010	1202	1323	1237	1830	2024	1610	1324	1597
Amphenicols	4	0		59	112	48	95	67	74	74	78
Betalactams (penicillins)				856	876	1002	970	1069	1164	1166	913
Penicillin G				*0*	*17*	*110*	*47*	*122*	*147*	*190*	*100*
Aminopenicillins	*424*	*690*		*856*	*860*	*893*	*923*	*947*	*1017*	*976*	*813*
Cephalosporins				872	1025	871	766	730	587	493	341
1st gen. cephalosporins	*939*	*915*		*872*	*1025*	*871*	*766*	*730*	*587*	*493*	*341*
3rd gen. cephalosporins				*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Sulfonamides and trimethoprim	1892	1975		2945	2747	2789	2784	2535	2072	2138	1891
Sullfonamides				*2454*	*2289*	*2324*	*2320*	*2112*	*1726*	*1781*	*1575*
Trimethoprim				*491*	*458*	*465*	*465*	*423*	*346*	*357*	*316*
Macrolides, lincosamides	428	316		721	653	717	574	673	720	592	673
Macrolides				*559*	*519*	*565*	*444*	*510*	*581*	*498*	*395*
Lincosamides				*161*	*134*	*152*	*130*	*164*	*139*	*94*	*278*
Aminoglycosides	150	111		95	79	76	76	70	62	54	41
Quinolones				19	17	23	22	22	22	22	16
Fluoroquinolones	*11*	*13*		*19*	*17*	*23*	*22*	*22*	*22*	*22*	*16*
Other Quinolones (Oxolinic acid)	*20*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pleuromutilines	95	110		48	73	66	43	44	30	23	14
Others	1	0		0	0	0	0	0	0	0	0
Total	**5636**	**5264**		**6816**	**6906**	**6829**	**7160**	**7236**	**6342**	**5885**	**5563**

[1] ESVAC harmonised expression of sales since 2010, however no effect the on the results of orally administered products.

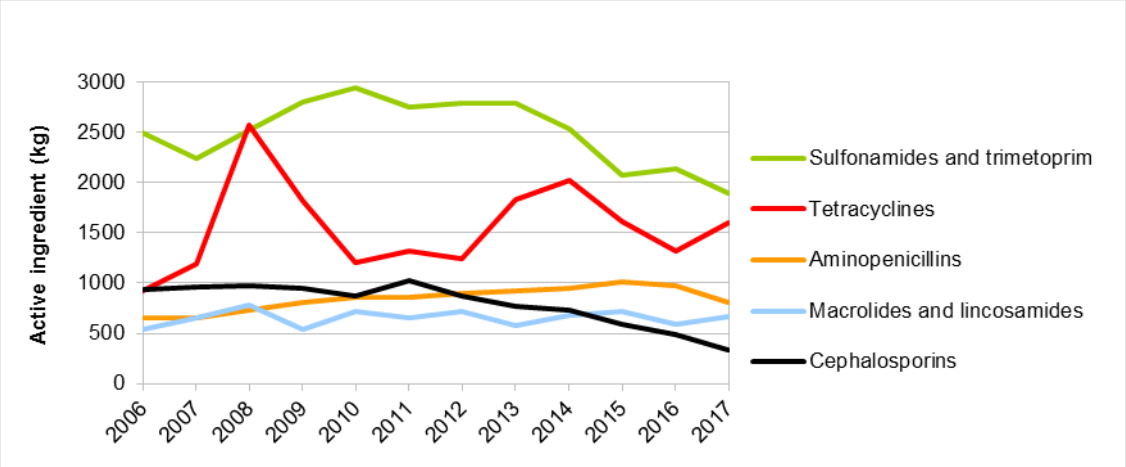

Figure 2. Sales of products intended for oral administration in Finland 2006-2017, kg active ingredient.

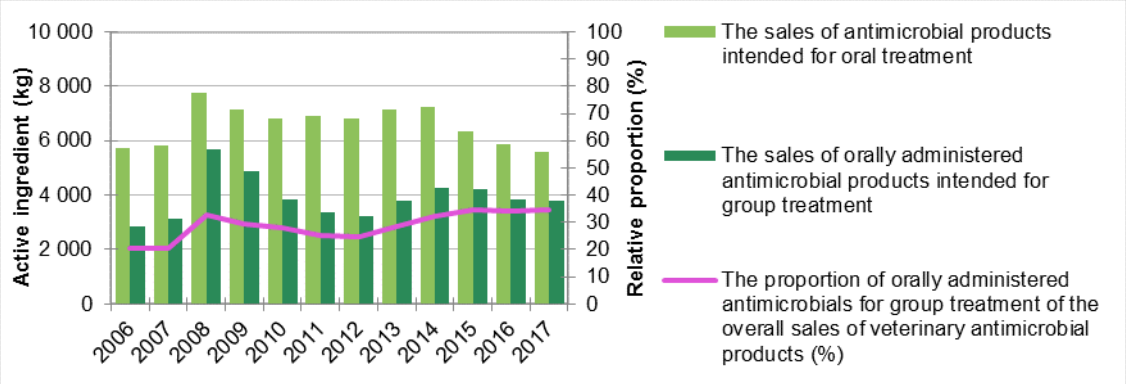

Figure 3. Total sales of orally administered products and the sales of products intended for group treatment 2006-2017.

1.2.3.2 Tablets for companion animals

In the beginning of 2010's the sales of veterinary antimicrobial tablets for companion animals were approximately 1900 kg/year. Since 2011, a decreasing trend can be seen and it has become more distinct in recent years. The sales of tablets in 2015 - 2017 decreased by 25% and in 2011 - 2017 by a total of 42% (Figure 4). The total sales of tablets for companion animals were 1200 kg in 2017.

The biggest changes have been in the sales of 1st generation cephalosporins that have fallen by almost 70% since 2011 with the majority of the change in the last two years. Notable is also the decrease in sales of fluoroquinolones and aminopenicillins since 2015 (-24% and -14% respectively).

Human medicinal products containing antimicrobial agents may also be used in companion animals, but the amount sold or the changes in sales are not known[4]. *E.g.* tablets containing combinations of trimethoprim and sulfonamides are no longer available as veterinary medicinal products[5] but whether this use has been replaced by other veterinary medicinal tablets or human medicinal tablets of the same antimicrobial class, and the extent of these changes, is not known.

It has been estimated that during the observation period, the number of dogs has somewhat increased and the number of cats has remained stable.

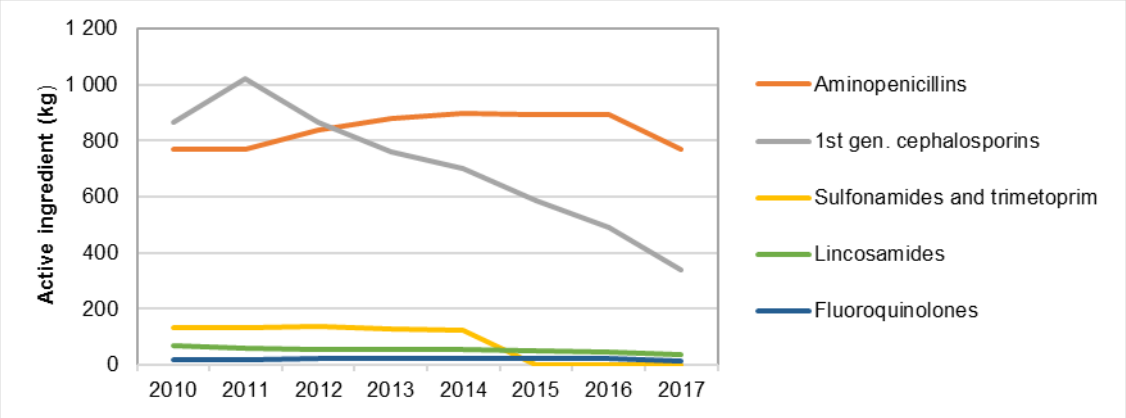

Figure 4. Sales of tablets for companion animals by antimicrobial class from 2010 to 2017.

[4] Sales data includes veterinary medicinal products only.
[5] Marketing authorisation of the last veterinary medicinal tablet with combination of trimethoprim and sulfonamide as active ingredient was withdrawn in 2014.

1.2.4 Intramammary products

The sales of intramammary products used during lactation decreased in 2016 but seemed to stabilise in 2017 (Table 4). Penicillin G, cloxacillin and cephalexin were the most used antimicrobial classes for lactating cows. The sales of antimicrobials for dry cows were stable with penicillin G and cloxacillin being the most used classes.

A decreasing trend in the number of intramammary tubes for lactation period sold per cow continued from 2015 to 2017. For intramammaries used for dry cow therapy the sales somewhat increased (Figure 5).

Table 4. Sales of intramammary tubes for use during lactation and for dry cow therapy in Finland 2001, 2005 and 2010-2017, kg active substance.

Intramammary tubes, lactation phase	2001	2005		2010	2011	2012	2013	2014	2015	2016	2017
Penicillin	225	167	ESVAC harmonised sales since 2010	104	107	94	154	100	94	85	92
Other beta lactams	270	162		103	101	89	74	70	56	51	37
Aminopenicillins	*25*	*26*		*15*	*14*	*11*	*8*	*8*	*7*	*7*	*6*
Cephalexin	*169*	*68*		*29*	*30*	*31*	*27*	*22*	*18*	*15*	*13*
Cloxacillin	*76*	*67*		*60*	*56*	*47*	*39*	*41*	*31*	*29*	*19*
Aminoglycosides	414	81		29	12	1	0	0	0	0	0
Macrolides	0	1		1	1	0	0	0	0	0	0
Total	**909**	**411**		**237**	**220**	**185**	**168**	**170**	**150**	**136**	**129**

Intramammary tubes, dry cow	2001	2005		2010	2011	2012	2013	2014	2015	2016	2017
Penicillin[1]	29	40	ESVAC harmonised sales since 2010	35	38	28	48	37	44	47	50
Other beta lactams	125	89		67	62	54	47	54	36	36	30
Aminopenicillins	*7*	*7*		*6*	*6*	*5*	*4*	*3*	*2*	*2*	*3*
Cephalexin	*45*	*16*		*6*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
Cloxacillin	*73*	*65*		*55*	*55*	*49*	*43*	*50*	*35*	*34*	*26*
Aminoglycosides	67	34		24	20	12	16	15	18	19	20
Others	3	0		0	0	0	0	0	0	0	0
Total	**224**	**163**		**126**	**120**	**94**	**101**	**106**	**98**	**102**	**100**

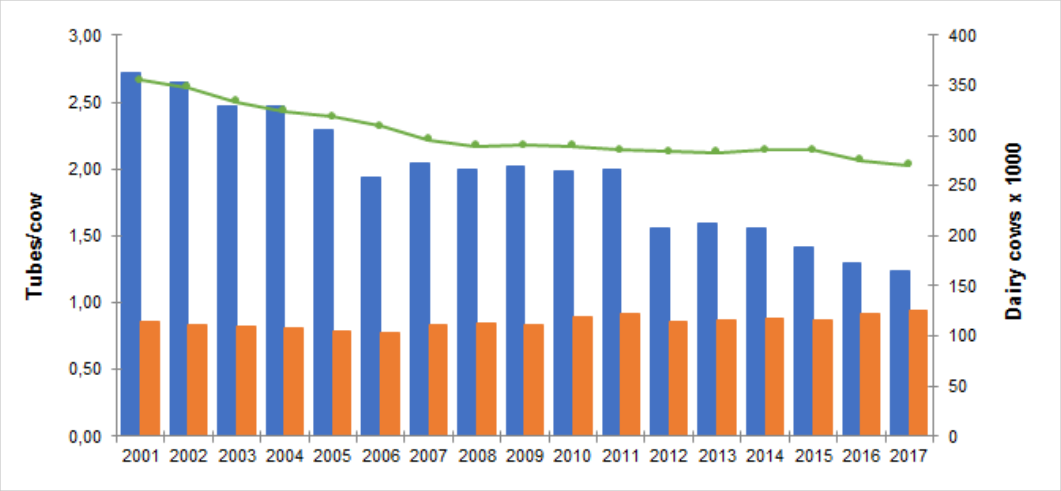

Figure 5. Antimicrobials for intramammary use during lactation period (blue column) and for dry cow period (orange column) and the number of dairy cows (green curve).

1.2.5 Highest priority critically important antimicrobials, HPCIA

According to WHO classification, antimicrobials that have the highest priority in treatment of certain severe infections in humans are quinolones, cephalosporins (3rd generation and higher), macrolides, ketolides, glycopeptides and polymyxins (WHO

2017). Of these, 3rd generation cephalosporins, fluoroquinolones and macrolides are available as veterinary antimicrobials in Finland.

The sales of HPCIAs in Finland has remained low and further decreased during the observation period. Since 2015, critically important antimicrobials have been allowed to be used in animals only according to susceptibility testing results, or on epidemiological or veterinary medicinal grounds if there is no other efficacious treatment available. In addition, specific control and guidance measures have been directed to high users of HPCIA.

Third generation cephalosporins are only available as injectable products. Over 90% decrease in their sales was observed since 2015 and in 2017, their sales were only 1 kg (Tables 1 and 2).

The sales of fluoroquinolones decreased by 15%. The biggest drop in percentages (24%) took place in oral products that are only available as tablets for companion animals. In 2017, the sales of injectable fluoroquinolones were the lowest since year 2000 (Tables 1, 2 and 3).

The sales of macrolides have traditionally fluctuated significantly between the years. A peak in sales was observed in 2015 but since then, the sales have decreased by 31%. The change is mainly due to the decrease in sales of orally administered products intended for food-producing animals as their proportion of the total sales of macrolides is very high (approximately 97%). The sales of injectable macrolides peaked in 2016 to 19 kg but decreased year after to 13 kg (-30%).

1.3 Coccidiostats and antimicrobial feed additives

Evira monitors the annual consumption of feed additives by collecting data from feed manufacturers. In Finland, the coccidiostats monensin and narasin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production. The overall use of coccidiostats has been increasing during the last decade and was its highest in 2016 (Table 4).

Table 5. The use of coccidiostats, antimicrobial feed additives and other substances in feed in Finland in 2005 and 2010-2017 (kg active substance/year).

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

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

2 Antimicrobial resistance in zoonotic bacteria

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

The prevalence of *Salmonella* spp. in cattle, pigs and poultry as well as in meat and eggs is monitored through the national *Salmonella* control programme (23/EEO/1995; 20/EEO/2001, 1172/2009, 1173/2009). The objective of the programme is to maintain the annual incidence of salmonella contamination among food-producing animals and in the respective meat and eggs at 1% or below. The results of the programme show that salmonella in food-producing animals and foods of animal origin is rare in Finland. The antimicrobial susceptibility of all salmonella isolates from cattle, pigs, poultry and domestic food is determined in the FINRES-Vet programme. Isolates from clinical cases and domestic food industry's in-house control systems are also included.

Details of the susceptibility testing are described in Appendix 3. Correspondences between the verbal descriptions of the resistance levels and the actual percentage categories are also given in Appendix 3.

In total, 26 and 28 *Salmonella* isolates obtained from food-producing animals in Finland in 2016 and 2017, respectively, were included in the resistance monitoring. The different serovars encountered from each food-producing animal species are shown in Appendix 4. *S*. Typhimurium was the most common serotype (n=22), followed by S. Derby (n=11), *S*. Enteritidis (n=5) and *S*. Mdandaka (n=5). The majority of the isolates were susceptible to the tested antimicrobials and only five isolates (9%) were resistant to one or two antimicrobials (Table 6). No multiresistant isolates were found.

In 2016, one strain from domestic food was obtained. This was of serotype *S*. Enteritidis and it originated from a bovine meat sample. In 2017, one *S*. Typhimurium from domestic turkey meat was obtained. Both isolates were susceptible to all antimicrobials tested.

Table 6. Distribution of MICs for *Salmonella enterica* in food-producing animals in 2016 (n=26) and in 2017 (n=28).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
				0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	2016	0.0	0.0-12.9							69.2	23.1	7.7									
	2017	0.0	0.0-12.1							92.9	3.6	3.6									
Azithromycin	2016	ND										50.0	38.5	11.5							
	2017	ND										50.0	46.4	3.6							
Cefotaxime	2016	0.0	0.0-12.9					92.3	7.7												
	2017	0.0	0.0-12.1					100													
Ceftazidime	2016	0.0	0.0-12.9						100												
	2017	0.0	0.0-12.1						100												
Chloramphenicol	2016	3.8	0.7-18.9										92.3	3.8	3.8						
	2017	0.0	0.0-12.1										96.4	3.6							
Ciprofloxacin	2016	7.7	2.1-24.1	46.2	42.3	3.8		7.7													
	2017	0.0	0.0-12.1	50.0	42.9	7.1															
Colistin	2016	0.0	0.0-12.9							84.6	15.4										
	2017	0.0	0.0-12.1							89.3	10.7										
Gentamicin	2016	0.0	0.0-12.9						84.6	15.4											
	2017	0.0	0.0-12.1						85.7	14.3											
Meropenem	2016	0.0	0.0-12.9		100																
	2017	0.0	0.0-12.1		92.9	7.1															
Nalidixic acid	2016	7.7	2.1-24.1									84.6	7.7					7.7			
	2017	0.0	0.0-12.1									96.4	3.6								
Sulfamethoxazole	2016	0.0	0.0-12.9											65.4	23.1	7.7	3.8				
	2017	7.1	2.0-22.6										10.7	53.6	28.6						7.1
Tetracycline	2016	0.0	0.0-12.9								92.3		7.7								
	2017	0.0	0.0-12.1								100										
Tigecycline	2016	ND						76.9	15.4	7.7											
	2017	ND						78.6	17.9	3.6											
Trimethoprim	2016	0.0	0.0-12.9					92.3	7.7												
	2017	0.0	0.0-12.1					89.3	7.1	3.6											

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

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

The *Campylobacter jejuni* isolates from broilers in 2016-2017 were obtained from the Finnish campylobacter control programme. The samples were collected at slaughter with the caeca from 10 birds per slaughter batch pooled for examination. The numbers of isolates tested were 83 and 30 in 2016 and 2017, respectively.

Campylobacter jejuni were also isolated from cattle from the faecal samples taken at the slaughterhouses. Altogether, *C. jejuni* was isolated from 21% (48/233) of the samples and all were included for susceptibility testing.

From pigs, *Campylobacter coli* were obtained from caecum samples collected at slaughter. *C. coli* were isolated from 73% (203/279) of the samples and the susceptibility results were obtained from 196 isolates.

From fur animals, *Campylobacter jejuni* isolates were collected from samples sent for diarrhea examination.

2.2.1 *Campylobacter jejuni* from broilers

Antimicrobial resistance in campylobacter isolates from broilers has been monitored systematically since 2003 from the isolates gathered annually from the national Campylobacter control programme. Resistance levels in *C. jejuni* have been quite stable for many years and resistance against the tested antimicrobials have mainly been low (Figure 6). Resistance levels against erythromycin, gentamicin and streptomycin have remained low. However, resistance to tetracycline and quinolones was more commonly found in 2014 and 2016 with the highest peek detected in 2014.

In 2016, resistance to nalidixic acid, ciprofloxacin and tetracycline was detected in 14.5%, 8.4% and 6.0% of the isolates, respectively (Table 7). In 2017, resistance was not detected to any of the examined antimicrobials.

Antimicrobials are seldom used in broiler production chain in Finland and not at all in the broiler production flocks since 2009 (Animal Health ETT ry) so the reason for the detected resistance traits is not known.

Table 7. Distribution of MICs for *Campylobacter jejuni* from broilers in 2016-2017.

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)											
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	2016	8.4	3.7-17.1	78.3	8.4	4.8			1.2	3.6		3.6			
	2017	0.0	0.0-14.1	96.7	3.3										
Erythromycin	2016	0.0	0.0-5.5				100								
	2017	0.0	0.0-14.1				100								
Gentamicin	2016	0.0	0.0-5.5	7.2	39.8	50.6	2.4								
	2017	0.0	0.0-14.1	10.0	56.7	30.0	3.3								
Nalidixic acid	2016	14.5	8.0-24.3				1.2	6.0	71.1	7.2		1.2	2.4	10.8	
	2017	0.0	0.0-14.1				3.3	6.7	66.7	23.3					
Streptomycin	2016	1.2	0.1-7.5		2.4	9.6	67.5	18.1	1.2			1.2			
	2017	0.0	0.0-14.1			20.0	70.0	20.0							
Tetracycline	2016	6.0	2.2-14.1			92.8	1.2			1.2	2.4			2.4	
	2017	0.0	0.0-14.1			100									

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

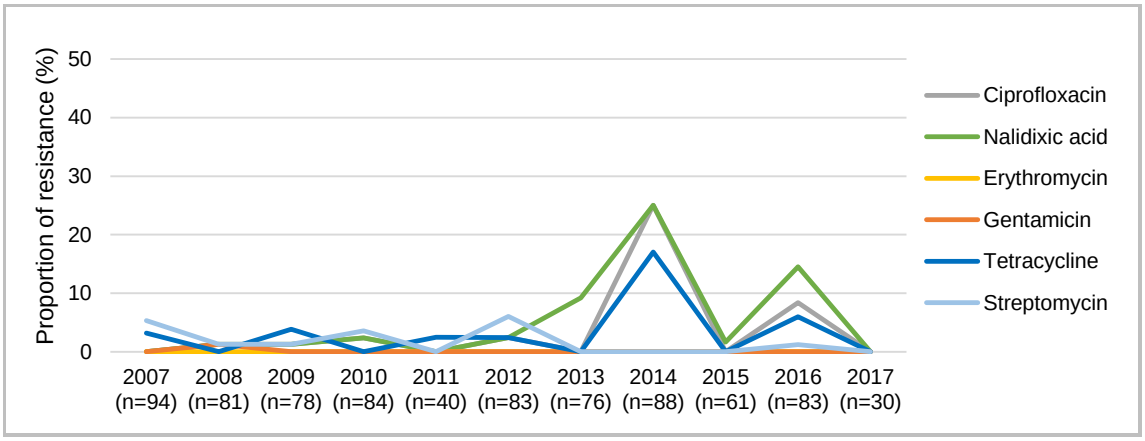

Figure 6. Resistance in Campylobacter jejuni isolated from broilers at slaughter in Finland in 2007-2017. Number of isolates tested each year in brackets.

2.2.2 *Campylobacter jejuni* from cattle

C. jejuni have been isolated in the FINRES-Vet monitoring programme from cattle every third or fourth year since 2003. Between 2003 and 2009, antimicrobial resistance has been low against the tested antimicrobials (Figure 7). However, resistance was notably higher to quinolones in 2012 and also in 2016. In 2016, resistance to nalidixic acid and ciprofloxacin was 16.7% and 10.4%, respectively (Table 8). Resistance to tetracycline, erythromycin and streptomycin was at low level, and no resistance was found against gentamicin.

Table 8. Distribution of MICs for *Campylobacter jejuni* from cattle in 2016 (n=48).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)											
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	10.4	3.9-23.4	72.9	12.5	4.2			2.1	8.3					
Erythromycin	2.1	0.1-12.5				97.9			2.1					
Gentamicin	0.0	0.0-9.2	6.2	50.0	41.7	2.1								
Nalidixic acid	16.7	8.0-30.8					8.3	52.1	16.7	6.2		4.2	12.5	
Streptomycin	4.2	0.7-15.5		4.2	2.1	68.8	14.6	6.2				4.2		
Tetracycline	2.1	0.1-12.5			97.9			2.1						

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

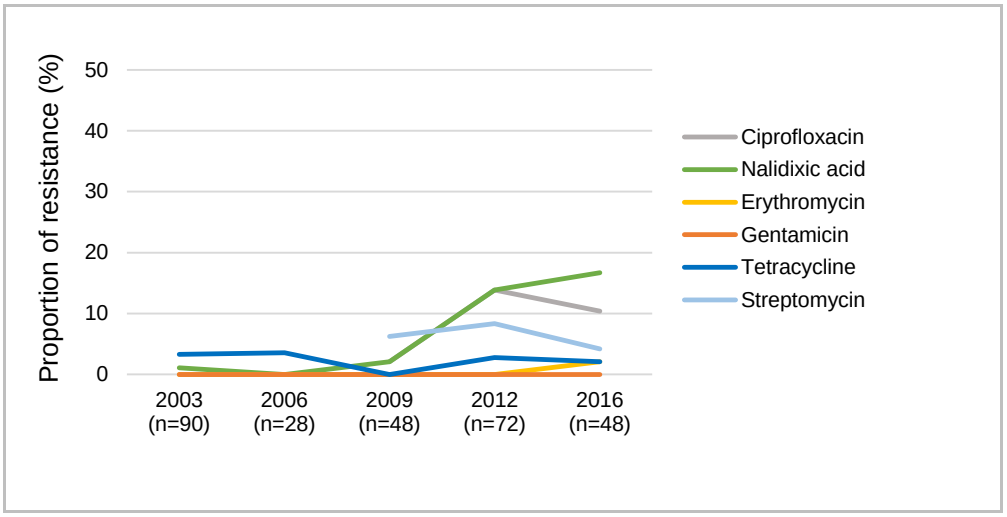

Figure 7. Resistance in *Campylobacter jejuni* isolated from cattle at slaughter in Finland in 2003-2016. Number of isolates tested each year in brackets.

2.2.3 *Campylobacter coli* from pigs

Antimicrobial resistance in *C. coli* isolated from pigs has been monitored every third year since 2004. In the 2010's, resistance against nalidixic acid and ciprofloxacin has been moderate (Figure 8). Resistance to ciprofloxacin was highest in 2010 (26.4%) and has since decreased to 18.3% in 2013 and 16.8% in 2017. Resistance to tetracycline, erythromycin and gentamicin has remained low or rare (Figure 8, Table 9).

Table 9. Distribution of MICs for *Campylobacter coli* from pigs in 2017 (n=196).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)											
			≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	16.8	12.0-22.9	67.3	15.8			0.5	2.6	7.7	5.1	1.0			
Erythromycin	1.5	0.4-4.7				83.7	12.2	2.6						1.5
Gentamicin	0.0	0.0-2.4	1.5	5.6	45.4	47.4								
Nalidixic acid	17.3	12.4-23.5						30.1	46.9	5.6	0.5	0.5	16.3	
Streptomycin	11.2	7.3-16.7			1.0	3.1	27.6	57.1	0.5			10.7		
Tetracycline	0.0	0.0-2.4			99.0	1.0								

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

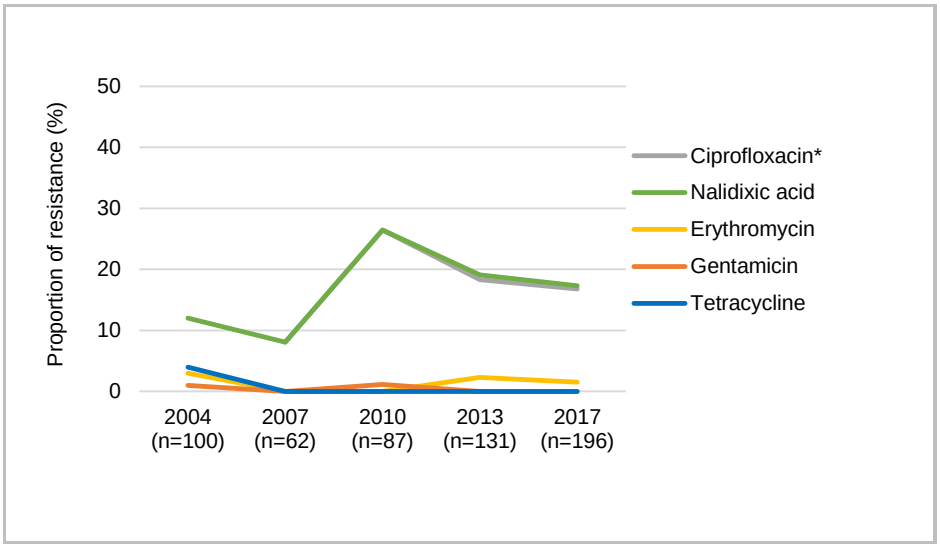

Figure 8. Resistance in *Campylobacter coli* isolated from pigs at slaughter in Finland in 2004-2017. Number of isolates tested each year in brackets. *In 2004, enrofloxacin was tested (resistance was 9%).

2.2.4 *Campylobacter jejuni* from fur animals

Campylobacter spp. are isolated from fur animals as part of diarrhea examination. *Campylobacter jejuni* infections in fur animals are treated with antibiotics and these bacteria pose also a risk to the farmers. The antimicrobial resistance in *C. jejuni* in fur animals is included in the FINRES-Vet report for the first time.

Tetracycline resistance was common: 38.5% in 2016 and 32.8% in 2017 (Table 10). Resistance to ciprofloxacin and nalidixic acid was 15.4% in 2016 and 17.2% in 2017. Resistance to erythromycin or gentamicin was not detected, and resistance to streptomycin was not detected in 2016, and was at low level in 2017 (1.6%).

Table 10. Distribution of MICs for *Campylobacter jejuni* from fur animals in 2016 (n=13) and 2017 (n=64).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	2016	15.4	2.7-46.4	69.2	15.4					15.4					
	2017	17.2	9.3-29.1	81.2	1.6			1.6	1.6	12.5	1.6				
Erythromycin	2016	0.0	0.0-28.3				100								
	2017	0.0	0.0-7.1				100								
Gentamicin	2016	0.0	0.0-28.3		53.8	46.2									
	2017	0.0	0.0-7.1	1.6	46.9	48.4	3.1								
Nalidixic acid	2016	15.4	2.7-46.4					7.7	69.2	7.7			7.7	7.7	
	2017	17.2	9.3-29.1					17.2	60.9	7.7			1.6	15.6	
Streptomycin	2016	0.0	0.0-28.3			15.4	46.2	15.4	23.1			1.2			
	2017	1.6	0.1-9.6		1.6	9.4	67.2	14.1	6.2				1.6		
Tetracycline	2016	38.5	15.2-67.8			61.5		7.7				23.1	7.7		
	2017	32.8	21.9-45.8			67.2			1.6		7.8	14.1	7.8	1.6	

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

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

Screening of extended-spectrum beta-lactamase producing *E. coli* from food-producing animals and meat thereof is part of the harmonised monitoring in all EU member states (Comission Decision 2013/652/EU). In Finland, these bacteria were screened from broilers, cattle and pigs, as well as meat thereof. ESBL-, AmpC- and carbapenemase-producing *E. coli* have been screened from the faecal or caecal samples taken at the slaughterhouses.

Methicillin-resistant *Staphylococcus aureus* (MRSA) was screened in slaughter batches of pigs from the nasal swab samples taken at slaughter in a year-long survey between September 2016 and September 2017. The prevalence of MRSA was also investigated in fresh pork samples in 2017. Details of the isolation procedure and confirmatory tests are described in Appendix 3.

3.1 ESBL/AmpC- and carbapenemase-producing *E. coli* in broilers, cattle and pigs

In 2016, extended-spectrum beta-lactamase producing *E. coli* were screened from broilers and cattle from caecal and faecal samples, respectively, collected at slaughterhouses. In 2017, these bacteria were screened from caecal samples of pigs taken at slaughter.

From broilers, ESBL- or AmpC-producing *E. coli* was isolated from 14% (44/306) of the caecal samples in 2016 (Table 11). ESBL *E. coli* was isolated from 11 (3.6%) samples and presumptive AmpC (e.g. resistant to cefoxitin) *E. coli* from 33 samples (11.1%). One isolate which was phenotypically an ESBL producer, was also resistant to cefoxitin. The prevalence of ESBL/AmpC-producing *E. coli* in broilers has increased compared to year 2014 when these bacteria were isolated from 7% of the samples (FINRES-Vet 2013-2015).

In cattle and pigs, the prevalence of ESBL- or AmpC-producing *E. coli* was 1% and 3%, respectively (Table 11). All isolates (n=3) originating from cattle were phenotypically presumptive AmpC-producers as they were resistant to cefoxitin. From pigs, ESBL *E. coli* was isolated from one (0.3%) sample and presumptive AmpC *E. coli* were obtained from seven (2.3%) samples. No carbapenemase-producing *E. coli* from food-producing animals was found.

3.2 ESBL/AmpC- and carbapenemase-producing *E. coli* in meat from broilers, cattle and pigs

In 2016, extended-spectrum beta-lactamase producing *E. coli* were screened from 309 fresh broiler meat samples collected at retail. In 2017, the monitoring included 302 fresh beef and 301 fresh pork samples. Individual samples represented different

production batches. The number of products of foreign origin was 23 for beef and 14 for pork samples. All broiler meat samples were of domestic origin.

In fresh broiler meat, ESBL- or AmpC-producing *E. coli* were isolated from 22% (68/309) of the samples (Table 11). Isolates with an ESBL phenotype were found in 5% of the samples and the prevalence of presumptive AmpC was 17%. One ESBL isolate was also resistant to cefoxitin.

ESBL/AmpC-producing *E. coli* was not detected in any of the beef or pork samples in 2017. These results are similar than in 2015 when only one presumptive AmpC was found in pork. Carbapenemase-producing *E. coli* was not isolated in any of the fresh meat samples in 2016-2017.

Table 11. Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing *E. coli* in food-producing animals and meat in 2016-2017.

Year	Source	Sampling stage	Nr of samples	Nr of ESBL[1]	Nr of AmpC[1]	Nr of CPE	% ESBL/AmpC
2016	Broilers	at slaughter	306	11 (3.6%)[2]	33 (11.1%)	0	14%
2016	Cattle	at slaughter	233 [3]	0	3 (1.3%)		1%
2016	Broiler meat	at retail	309	15 (4.9%)	53 (17.1%)[4]	0	22%
2017	Pigs	at slaughter	299	1 (0.3%)	7 (2.3%)	0	3%
2017	Pork, fresh[5]	at retail	301	0	0	0	0%
2017	Beef, fresh[6]	at retail	302	0	0	0	0%

[1] based on phenotypic characterization, see appendix 3.
[2] one isolate was resistant also to cefoxitin
[3] carbapenemase-producing *E. coli* was screened with specific plates from 204 samples
[3] phenotype of one isolate was confirmed only with AmpC & ESBL ID Set (D68C, Mast Diagnostics, UK)
[5] 14 pork samples were of foreign origin
[6] 23 beef samples were of foreign origin

3.3 MRSA in pigs

MRSA was found from 47 (77%) slaughter batches. The *spa* types found were: t034 (n=32), t2741 (n=25), t011 (n=9), t108 (n=6), t1250 (n=1), t1255 (n=1) and t17061 (n=1). From one slaughter batch, up to three different *spa* types were detected. MRSA was now more commonly detected in slaughter pigs compared to previous survey carried out in 2009-2010 with the corresponding result of 22%. Some change in the *spa* type profile was also noted. In 2009-2010, the most common *spa* types were t108 and t127 when in 2016-2017, the types t034 and t2714 were the most prevalent. People who are constantly in contact with pigs, have an increased risk of becoming an MRSA carrier.

3.4 MRSA in pork

Of the 220 fresh pork samples analysed, MRSA was found in 13 (6%) samples. Twelve of these were of domestic origin. Of all the samples tested, 202 samples were of domestic origin. Three different *spa* types were detected, t034 (n=11), t011 (n=1) and t2741 (n=1) which belong to the livestock-associated clonal complex (CC) 398. Same *spa* types have also been found in pigs in Finland. Compared to previous survey in 2015, MRSA was now slightly more common in pig meat at retail. In 2015, MRSA was found in 3% of the fresh pork meat samples investigated.

4 Antimicrobial resistance in animal pathogens from food-producing animals

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

4.1 *Escherichia coli* from pig enteritis

Escherichia coli isolates from pig enteritis cases were obtained from faecal or post-mortem samples submitted to Evira. All isolates were confirmed by PCR to be enterotoxigenic. Altogether, 47 and 51 *E. coli* isolates from 23 and 24 farms were included from the years 2016 and 2017, respectively. However, the results are not representative of the whole Finnish porcine enteritis *E. coli* population due to the low number of isolates, as well as due to the fact that at least part of the isolates are likely to originate from farms with diarrheal problems and higher than average antimicrobial usage. The annual MIC distributions are given in Table 12.

As in previous years, multiresistance (resistance to ≥3 antimicrobial classes) was commonly detected with 38% and 39% multiresistant isolates found in 2016 and 2017, respectively.

Similarly as before, resistance was commonly detected against ampicillin (31.9% and 37.4%), ciprofloxacin (17% and 17.7%), tetracycline (40.4% and 45%), streptomycin (36.2% and 33.4%), sulfamethoxazole (42.5% and 41.2%) and trimethoprim (31.9% and 31.4%), all percentages respective to 2016 and 2017.

Resistance against 3rd generation cephalosporins was detected in eight isolates from four farms in 2016 and eleven isolates from five farms in 2017. Eleven and six isolates were AmpC producers in 2016 and 2017, respectively. No ESBL-producers were detected.

No resistance was detected against colistin or gentamicin. Resistance to florfenicol and kanamycin was at low level (<10%).

Table 12. Distribution of MICs for *Escherichia coli* from porcine enteritis in 2016 (n=47) and 2017 (n=51).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)																
				0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	2016	31.9	20.4- 46.2							48.9	17.0	2.1		6.4	17.0		2.1	6.4			
	2017	37.4	25.3- 51.0							39.2	17.6	3.9	2.0	2.0	5.9	2.0		27.5			
Cefotaxime	2016	14.9	7.4-27.7		2.1	57.4	14.9	8.5	12.8	2.1											
	2017	11.8	5.5-23.4		2.0	51.0	31.4	3.9	5.9	5.9											
Ceftazidime	2016	14.9	7.4-27.7					68.1	17.0	12.8	2.1										
	2017	21.6	12.5-34.6					70.6	7.8	13.7	2.0		2.0	3.9							
Chloramphenicol	2016	12.8	6.0 - 25.2								12.8	56.9	12.8	2.1	12.8						
	2017	7.9	3.1-18.5								9.8	68.6	11.8	2.0	5.9	2.0					
Ciprofloxacin	2016	17.0	8.9- 30.1	31.9	44.7	6.4	10.6	4.3			2.1										
	2017	17.7	9.6-30.3		70.6	11.8	11.8	3.9	2.0												
Colistin	2016	0.0	0.0-0.1						73.9	23.9	2.2										
	2017	0.0	0.0-0.1						35.3	54.9	9.8										
Enrofloxacin	2016	14.9	8.9 - 30.1				85.1	8.5	4.3	2.1											
	2017	11.8	5.5-23.4				88.3	7.8	2.0	2.0											
Florfenicol	2016	2.1	0.4 -11.1									40.4	57.4		2.1						
	2017	0.0	0.0-0.1									70.6	27.5	2.0							
Gentamicin	2016	0.0	0.0-0.1				2.1	12.8	70,2	14.9											
	2017	0.0	0.0-0.1					11.8	66.7	17.6	3.9										
Kanamycin	2016	0.0	0.0-0.1										100								
	2017	7.8	3.1-18.5										92.2		7.8						
Nalidixic acid	2016	19.2	10.4 - 32.6							4.3	61.7	12.8	2.1		12.8		2.1	4.3			
	2017	15.7	8.2-28.0							3.9	56.9	17.6	3,9	2.0	9.8	5.9					
Streptomycin	2016	36.2	24.0 - 50.5								14.9	29.8	17.0	2.1	21.3	4.3	8,5		2.1		
	2017	33.4	22.0-47.0								9.8	29.4	19.6	7.8	2.0	5.9	5.9	9.8	9.8		
Sulfamethoxazole	2016	42.5	29.5 -56.7										40.4	14.9	2.1			2.1		2.1	38.3
	2017	41.2	28.8- 54.8										35.3	21.6	2.0					3.9	37.3
Tetracycline	2016	40.4	28.3 - 55.7							44.7	14.9				4.3	19.1	17.0				
	2017	45.1	32.3- 58.6							47.1	7.8				9.8	33.3		2.0			
Trimethoprim	2016	31.9	20.4 - 46.2				25.5	23.4	10.6	6,4	2,1		2.1		29.8						
	2017	31.4	20.3-45.0				25.5	21.6	13.7	2.0	5,9		2.0		29.4						
Trimethoprim/ sulfamethoxazole[1]	2016	29.8	18.7 - 44.0						70.2				29.8								
	2017	35.3	23.6-49.0						64.7		5.9		29.4								

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

4.2 *Actinobacillus pleuropneumoniae* from respiratory diseases of pigs

A. pleuropneumoniae is the most import respiratory pathogen in growing pigs in Finland. Low level resistance (4.5%) against tiamulin was seen in 2016 (Table 13). Intermediate susceptibility (20% in 2017) against oxytetracycline has decreased compared to 2015 (67%, FINRES-Vet 2013-2015).

Table 13. Distribution of MICs for *Actinobacillus pleuropneumoniae* from pigs in 2016 (n=22) and 2017 (n=15).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)									
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Florfenicol	2016	0.0	0.0-18.5		100									
	2017	0.0	0.0-25.3		93.3		6.7							
Ceftiofur	2016	0.0	0.0-18.5		100									
	2017	0.0	0.0-25.3		100									
Penicillin[1]	2016			18.2	45.5	36.4								
	2017			20.0	26.7	53.3								
Oxytetracycline	2016	0.0	0.0-18.5			95.5	4.5							
	2017	0.0	0.0-25.3			80.0	20.0							
Tiamulin	2016	4.5	0.2-24.8						31.8	59.1	4.5	4.5		
	2017	0.0	0.0-25.3						13.3	26.7	60.0			
Tulathromycin	2016	0.0	0.0-18.5							18.2	77.3	4.5		
	2017	0.0	0.0-25.3								66.7	33.3		

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

4.3 *Brachyspira pilosicoli* from pigs

There are no standardised breakpoints established for *Brachyspira pilosicoli* from pigs. As a guide for the choice of antimicrobial for treatment of spirochaetal diarrhoea, a clinical breakpoint for tiamulin of >1 mg/L, for tylosin of >2 mg/L, for valnemulin of >1 mg/L and for lincomycin of >4 mg/L are used in Finland. With these breakpoints, 13.6% (2016) and 52.2% (2017) of *B. pilosicoli* isolates were resistant to tylosin, and 9.1% (2016) and 26.1% (2017) was resistant to lincomycin (Table 14). No resistance against valnemulin was detected. In 2016, no resistance for tiamulin was detected, but in 2017, one isolate had reduced susceptibility (4.4%). Resistance in *B. pilosicoli* has been at similar level in 2015 and 2017, and showed lower level in 2016, although the number of isolates tested each year was too small to draw any definite conclusions.

Table 14. Distribution of MICs for *Brachyspira pilosicoli* from pigs in 2016 (n=22) and 2017 (n=23).

Substance	Year	Distribution (%) of MICs (mg/L)													
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	2016			68.2	4.5	9.1	9.1	9.1							
	2017			60.9	4.3	8.7	17.4	4.3	4.3						
Lincomycin	2016					81.8			9.1	4.5	4.5				
	2017					60.9			13.0		17.4	8.7			
Tiamulin	2016		86.4	9.1	4.5										
	2017		82.6	13.0					4.3						
Tylosin	2016							86.4							13.6
	2017							47.8	8.7	4.3		4.3		34.8	
Tylvalosin	2016				86.4					4.5	9.1				
	2017				43.5	26.1		4.3	4.3		17.4	4.3			
Valnemulin	2016	81.8	4.5	9.1		4.5									
	2017	73.9	13.0	8.7		4.3									

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

During 2016-17, approximately 362 farms sent samples to Evira because of the respiratory disease problems, some of them more than one submission per year. One isolate per submission (and from each compartment if more than one was sampled) and per bacterial species was selected for susceptibility testing. In 2017, oxytetracycline resistant *H. somni* was detected in three sample batches (altogether five isolates tested) from one calf rearing farm (Table 15). This is the first time ever when resistance is seen in this species in Finland. Low level resistance against oxytetracycline was seen both in *P. multocida* and *M. haemolytica* (Tables 16 and 17). The situation regarding penicillin sensitivity in *M. haemolytica* is worrisome as the proportion of intermediate isolates is growing. As previously, resistance was mostly seen in isolates from specialised calf rearing units and was rare in samples from dairy farms.

Table 15. Distribution of MICs for *Histophilus somni* from bovine respiratory disease in 2016 (n=39) and 2017 (n=47).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	2016	0.0	0.0-11.2		100									
	2017	0.0	0.0-9.4		97.9	2.1								
Enrofloxacin	2016	0.0	0.0-11.2	100										
	2017	0.0	0.0-9.4	100										
Florfenicol	2016	0.0	0.0-11.2		97.4		2.6							
	2017	0.0	0.0-9.4		93.6	4.3	2.1							
Oxytetracycline	2016	0.0	0.0-11.2			89.7	10.3							
	2017	10.7	4.0-23.8			87.2	2.1			6.4 [1]	4.3 [1]			
Penicillin	2016	0.0	0.0-11.2	100										
	2017	0.0	0.0-9.4	100										
Tulathromycin	2016	0.0	0.0-11.2				12.8	23.1	48.7	15.4				
	2017	0.0	0.0-9.4				8.5	34.0	51.1	4.3	2.1			

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] oxytetracycline resistant strains are all from one large calf-rearing unit from three different sample batches

Table 16. Distribution of MICs for *Mannheimia haemolytica* from bovine respiratory disease in 2016 (n=76) and 2017 (n=60).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	2016	0.0	0.0-6.0		98.7	1.3								
	2017	0.0	0.0-7.5		100									
Danofloxacin	2016	0.0	0.0-6.0		98.7	1.3								
	2017	0.0	0.0-7.5		98.3	1.7								
Enrofloxacin	2016	0.0	0.0-6.0	97.4	1.3	1.3								
	2017	0.0	0.0-7.5	98.3		1.7								
Florfenicol	2016	0.0	0.0-6.0			52.6	46.1	1.3						
	2017	0.0	0.0-7.5		5.0	66.7	28.3							
Oxytetracycline	2016	1.3	0.1-8.1			93.4	5.3				1.3			
	2017	3.3	0.6-12.5			96.7					3.3			
Penicillin	2016	0.0	0.0-6.0	61.8	31.6	6.6								
	2017	1.7	0.1-10.2	66.7	16.7	15.0	1.7							
Tulathromycin	2016	0.0	0.0-6.0				2.6	60.5	34.2	2.6				
	2017	0.0	0.0-7.5				1.7	26.7	71.7					

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.

Table 17. Distribution of MICs for *Pasteurella multocida* from bovine respiratory disease in 2016 (n=215) and 2017 (n=241).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg/L)										
				≤0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ceftiofur	2016	0.0	0.0-2.2		99.5	0.5								
	2017	0.0	0.0-2.0		100									
Danofloxacin	2016	0.0	0.0-2.2	100										
	2017	0.0	0.0-2.0	100										
Enrofloxacin	2016	0.0	0.0-2.2	99.5	0.5									
	2017	0.0	0.0-2.0	100										
Florfenicol	2016	0.0	0.0-2.2		62.3	36.7	0.9							
	2017	0.0	0.0-2.0		66.8	33.2								
Oxytetracycline	2016	4.2	2.1-8.1			74.9	8.8	11.2	0.9		4.2			
	2017	2.1	0.8-5.1			83.8	6.6	7.5			2.1			
Penicillin	2016	0.5	0-3.0	97.7	1.9						0.5			
	2017	0.0	0.0-2.0	98.3	1.7									
Tulathromycin	2016	1.0	0.2-3.6				39.5	49.8	6.5	1.9	0.9	0.5	0.5	0.5
	2017	0.0	0.0-2.0				38.2	49.8	11.2	0.4	0.4			

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

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

Since 2014, colibasillosis has been a major problem in broiler production in Nordic countries including Finland. In years 2016 and 2017, the situation has not shown any improvements. In the end of year 2017, a vaccination program with an autogen vaccine against two major serotypes has started in some broiler chains. No antimicrobial treatments are targeted against *E. coli* in poultry. Number of isolates tested in 2016 and 2017 was significantly smaller than in previous years. Most of the samples are obtained from parent flocks.

Based on EUCAST ECOFFs, resistance to ampicillin was most commonly found (Table 18). Resistance to 3rd generation cephalosporins was slightly more common than in previous years. Fluoroquinolone resistance decreased back to a low level after a peak year in 2015. Multiresistance (resistance to ≥3 antimicrobial classes) was occasionally seen with one and three isolates in 2016 and 2017, respectively. In 2016, one AmpC producer and in 2017, one ESBL producer was detected.

Table 18. Distribution of MICs for *Escherichia coli* from broiler colibacillosis in 2016 (n=20) and 2017 (n=17).

Substance	Year	%R	95%C.I.	Distribution (%) of MICs (mg/L)																
				0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	2016	15.0	4.0-38.9							35.0	50.0					5.0		10.0			
	2017	17.7	6.2-41.0							35.3	47.1							17.6			
Cefotaxime	2016	5.0	0.9-23.6			75.0	20.0					5.0									
	2017	5.9	1.1-27.0			58.8	29.4	5.9				5.9									
Ceftazidime	2016	5.0	0.9-23.6					90.0	5.0			5.0									
	2017	17.7	6.2-41.0					76.5	5.9	11.8	5.9										
Ciprofloxacin	2016	5.0	0.9-23.6	15.0	60.0	20.0			5.0												
	2017	5.9	1.1-27.0	23.5	70.6				5.9												
Sulfamethoxazole	2016	0.0	0.0-16.1										65.0	35.0							
	2017	11.8	2.1-37.8										58.8	23.5	5.9						11.8
Tetracycline	2016	5.0	0.9-23.6							50.0	45.0				5.0						
	2017	17.7	6.2-41.0							47.1	23.5	11.8			11.8	5.9					
Trimethoprim	2016	0.0	0.0-16.1				5.0	30.0	45.0	20.0											
	2017	5.9	1.1-27.0				5.9	23.5	29.4	35.3					5.9						

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

4.6 *Staphylococcus aureus* from tenosynovitis in broilers

Staphylococcus aureus from broiler tenosynovitis cases were isolated from clinical and post-mortem samples submitted to Evira. All obtained *S. aureus* isolates were included. Nineteen isolates from 11 farms and 26 isolates from 12 farms were studied in 2016 and 2017, respectively. During the monitoring period, all of the isolates were susceptible to all tested antimicrobials (Table 19). No isolates were found to produce beta-lactamase and no MRSA isolates were found. Tenosynovitis is occasionally treated with antimicrobials in broiler parent flocks and only a small number of flocks are treated. Production flocks have not been treated with antimicrobials during 2016 and 2017 (Animal Health ETT ry).

Table 19. Distribution of MICs for *Staphylococcus aureus* from tenosynovitis in broilers in 2016 (n=19) and 2017 (n=26).

Substance	Year	%R	95%C.I.	Distribution (%) of MICs (mg/L)											
				0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64
Cefoxitin	2016	0.0	0.0-20.9				5.3			36.8	57.9				
	2017	0.0	0.0-16.0							88.5	11.5				
Oxacillin	2016	0.0	0.0-20.9				10.5	36.8	31.6	21.1					
	2017	0.0	0.0-16.0				34.6	30.8	34.6						
Oxytetracycline[1]	2016	0.0	0.0-20.9						100						
	2017[4]	0.0	0.0-40.2					12.5	87.5						
Penicillin[2]	2016	0.0	0.0-20.9			100									
	2017	0.0	0.0-16.0	57.7	23.1	19.2									
Tetracycline	2017[5]	0.0	0.0-20.0					100							
Trimethoprim/ Sulfamethoxazole[3]	2016	0.0	0.0-20.9					100							
	2017	0.0	0.0-16.0			73.1		26.9							

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

[1] EUCAST ECOFF of tetracycline used

[2] resistance profiles based on beta-lactamase production

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

[4] n=8

[5] n=20

5 Antimicrobial resistance in animal pathogens from companion animals and horses

Antimicrobial resistance figures from companion animal pathogens (dogs, cats, horses) were collected from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. In this context antimicrobial resistance corresponds to the proportion of resistant and intermediate isolates. The reporting period covers January 2014 – December 2017 and resistance figures concern solely bacterial isolates derived from clinical infections. Approximately 42% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 58% from private clinics. If the number of tested bacterial isolates for the bacterial species in question was large enough, data are presented separately for dogs, cats and horses. Otherwise collated data are presented. Details of the susceptibility testing method are described in Appendix 3.

5.1 *Staphylococcus aureus* from companion animals and horses

The material included 235 *S. aureus* isolates (42 – 100 isolates per year) from dogs, cats and horses. Antimicrobial resistance in this pathogen was low to very low (Figure 9), except for penicillin. Beta-lactamase results were available from 174 isolates, of which 55% were positive. Beta-lactamase production was more common in canine *S. aureus* isolates (80%, 85/106) than in equine isolates (16%, 5/32), ($p<0.0001$, *Chi*-square test) while there were no statistical difference in beta-lactamase production between canine and feline (72%, 26/36) *S. aureus* isolates. Oxacillin resistance (indicating the presence of MRSA) was at low level, ranging from 0 – 9%, being highest in 2014 and 2% in 2017. During the whole follow up period, there were seven confirmed MRSA cases (presence of *mec*A gene was verified) of which the majority originated from post-surgical wound infections.

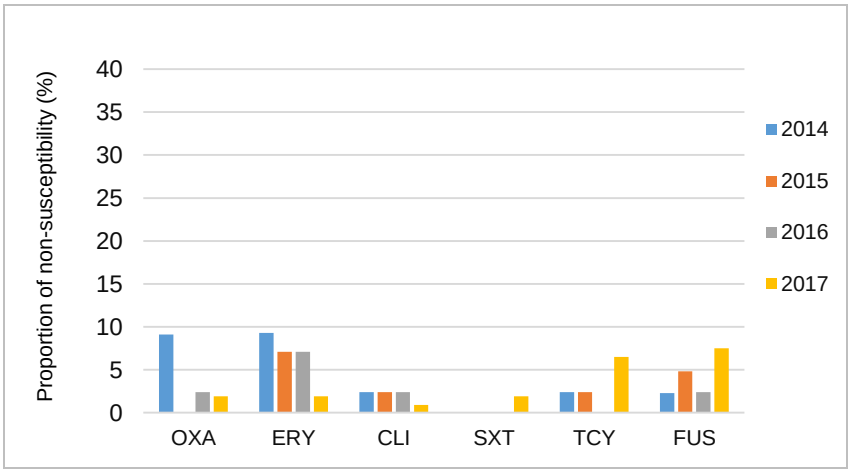

Figure 9. Antimicrobial non-susceptibility (%) in *Staphylococcus aureus* from horses, cats and dogs in 2014-2017. The number of tested isolates per year: 44 (2014), 42 (2015), 42 (2016), and 107 (2017).
OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TET, tetracycline; FUS, fusidic acid.

5.2 *Staphylococcus pseudintermedius* from dogs

Antimicrobial resistance was at a high level in *Staphylococcus pseudintermedius* for erythromycin, clindamycin and tetracycline (as well as for doxycycline) but descending figures were noted during 2015-2017. The proportion of MRSP isolates, as indicated by oxacillin non-susceptibility, was moderate (12-14%) in 2014-2016 but then decreased to 9% in 2017 (Figure 10). Sulfonamide-trimethoprim resistance remained stable – around 10-12% – during the whole period, while a decline in resistance was noted for fucidic acid (from 29 to 17%), chloramphenicol (from 19 to 14%), and enrofloxacin (from 7 to 5%) (Figure 11).

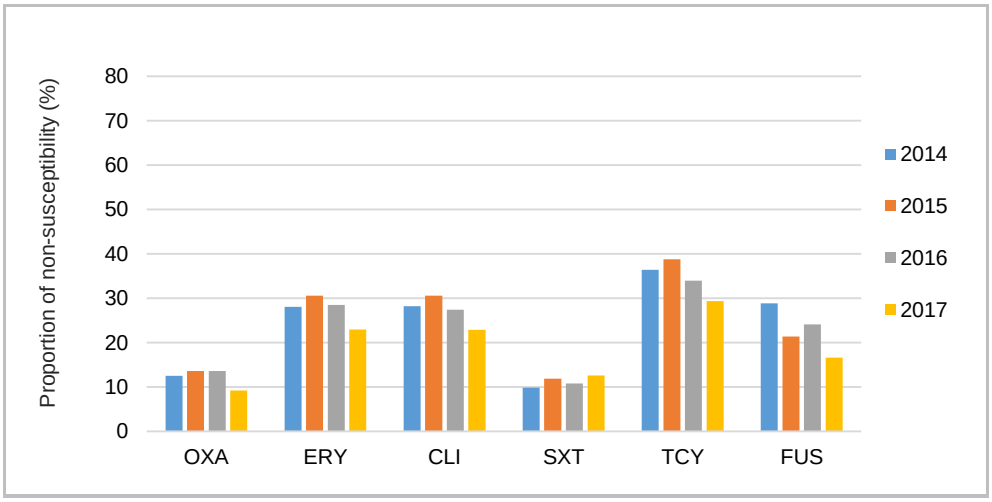

Figure 10. Antimicrobial resistance (%) in canine *Staphylococcus pseudintermedius* isolates in Finland in 2014-2017 for primary antimicrobial agents. Number of tested isolates per year were as follows: 401 (2014), 396 (2015), 477 (2016), 749 (2017). For each antimicrobial, there can be small variations from these numbers.
OXA, oxacillin; ERY, erythromycin; CLI, clindamycin; SXT, trimethoprim-sulfamethoxazole; TCY, tetracycline; FUS, fucidic acid

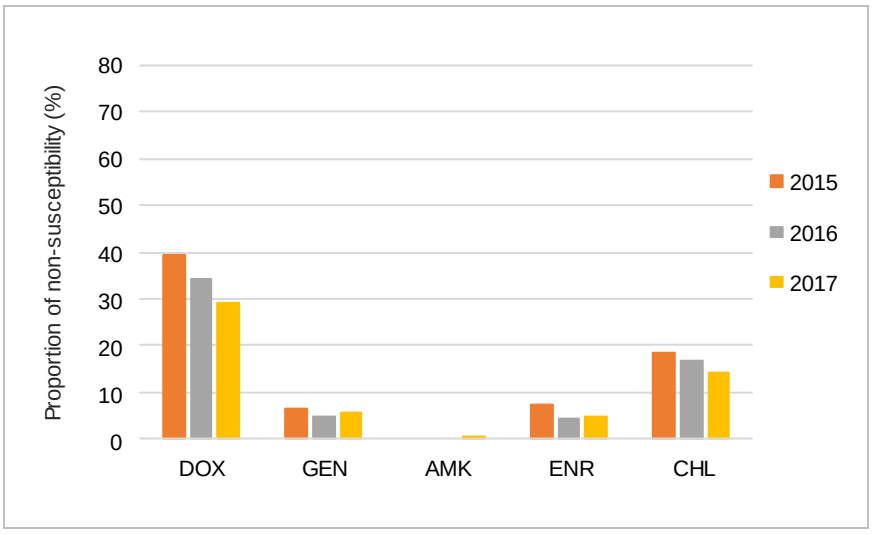

Figure 11. Antimicrobial resistance (%) in canine *Staphylococcus pseudintermedius* isolates in Finland in 2015-2017 for secondary antimicrobial agents. Number of tested isolates per year were as follows: 396 (2015), 477 (2016), 749 (2017). For each antimicrobial, there can be some variations from these numbers.
DOX, doxycycline; GEN, gentamicin; AMK, amikacin; ENR, enrofloxacin; CHL, chloramphenicol

5.3 *Escherichia coli* from dogs and cats

There were 1837 canine and 334 feline *E. coli* isolates in 2014-2017. This is the first time when the data concerning *E. coli* isolates are presented separately for both animal species. In general, feline isolates were more susceptible to antimicrobials than canine isolates. Resistance figures for canine *E. coli* are presented in Figure 12 and for feline isolates in Figure 13. Approximately 50% of canine *E. coli* isolates were resistant to ampicillin in 2017 while the respective figure for feline *E. coli* was 27%. Compared to the year 2016, amoxicillin-clavulanic acid resistance decreased four percentage points in canine isolates reaching 16% in 2017, while in feline isolates, the reduction in resistance was more prominent: from 19% in 2016 to 7% in 2017. In canine *E. coli*, sulfonamide-trimethoprim resistance was nearly 15% in 2017 while in isolates from cats it was only 3%. Enrofloxacin resistance has decreased during the last three years and was slightly under 7% in canine *E. coli* in 2017. In this animal species, the proportion of cefpodoxime non-susceptibility (indicating reduced susceptibility to 3rd generation cephalosporins) ranged from 6% to 9% and the lowest value was recorded for 2017. In feline *E. coli*, respective proportion ranged from 2 to 4%. Feline ESBL or AmpC are infrequent as 2/334 (0.6%) and 8/334 (2.4%) isolates were recorded as ESBL and AmpC, respectively. Table 20 lists the ESBL and AmpC proportions of canine *E. coli*.

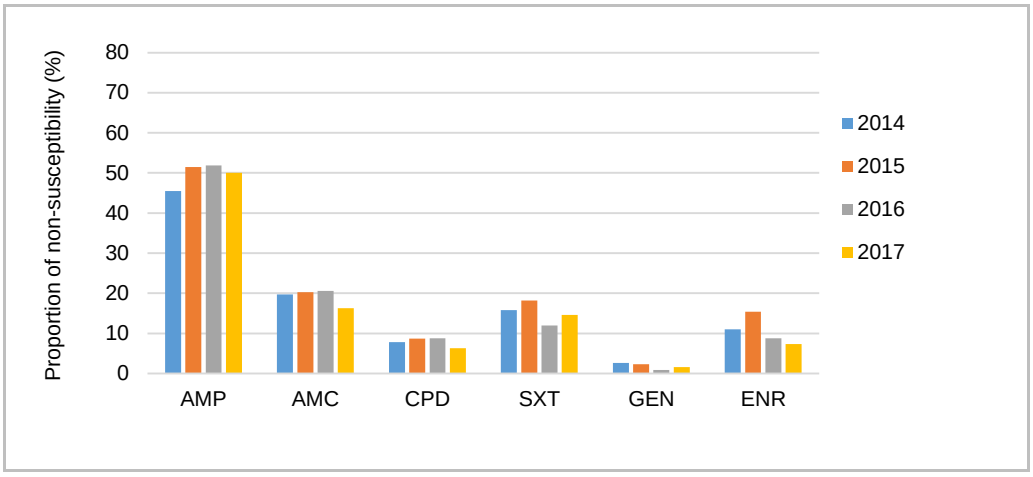

Figure 12. Antimicrobial resistance (%) in canine *E. coli* in Finland in 2014-2017. Number of tested isolates: 310 (2014), 390 (2015), 457 (2016), 680 (2017).
AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; ENR, enrofloxacin; SXT, trimethoprim-sulfamethoxazole

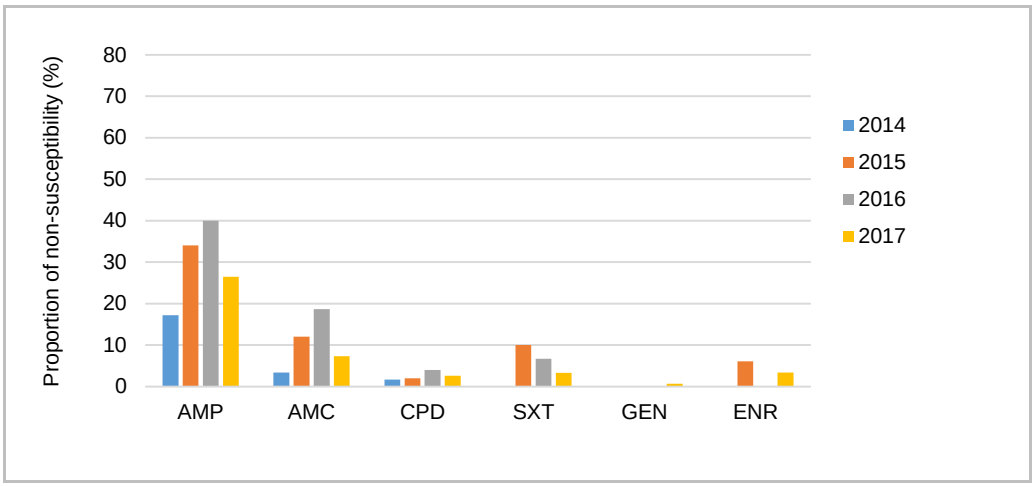

Figure 13. Antimicrobial resistance (%) in feline *E. coli* in Finland in 2014-2017. Number of tested isolates: 58 (2014), 50 (2015), 75 (2016), 151 (2017).
AMP, ampicillin; AMC, amoxicillin-clavulanic acid; CPD, cefpodoxime; ENR, enrofloxacin; SXT, trimethoprim-sulfamethoxazole

Table 20. Proportion of *E. coli* isolates with reduced susceptibility to cefpodoxime (CPD), and proportion of ESBL and AmpC positive isolates in canine *E. coli*, 2014-2017.

Year	CPD R (n/N)	ESBL	AmpC
2014	7.8% (24/309)	2.3%	5.2%
2015	8.7% (34/390)[1]	2.8%	4.6%
2016	8.8% (40/456)	2.2%	6.2%
2017	6.3% (43/680)	1.6%	3.5%

[1]Includes two isolates with an NDM-profile

5.4 *Escherichia coli* from horses

There were only 66 clinical *E. coli* isolates from horses during 2014-2017. Thus, the data are collated for periods of 2014-2015 and 2016-2017. Decrease in resistance was observed in all antimicrobial classes (Figure 14). Nonetheless, resistance percentages were still high for sulfamethoxazole-trimethoprim (42%) and ampicillin (49%) in the latter period. Gentamicin resistance decreased from 30 to 12%, fluoroquinolone (enrofloxacin) resistance from 17 to 7% and cefpodoxime resistance from 15 to 6%. For the whole period, five out of seven isolates with reduced susceptibility to cefpodoxime were recorded as ESBL *E.coli*.

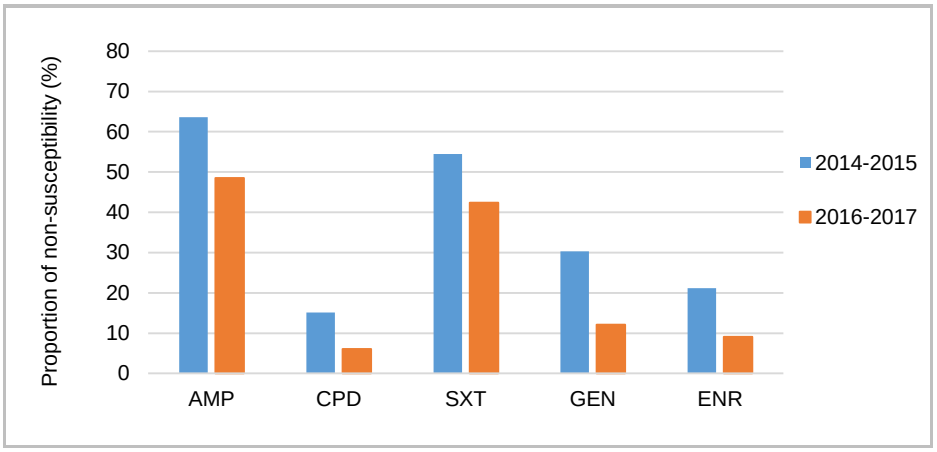

Figure 14. Antimicrobial non-susceptibility (%) in equine *E. coli* in Finland in 2014-2015 (n=33) and 2016-2017 (n=33).
AMP, ampicillin; CPD, cefpodoxime; SXT, trimethoprim-sulfamethoxazole; GEN, gentamicin; ENR, enrofloxacin.

5.5 *Streptococcus canis* from dogs

All *Streptococcus canis* isolates from dogs were susceptible to penicillin and nearly all to sulfamethoxazole-trimethoprim (Figure 15). Erythromycin and clindamycin resistance rates were rather stable: in 2017, 9% and 15% of isolates showed resistance to these antimicrobials, respectively. Tetracycline resistance was at high level although a decreasing tendency was observed.

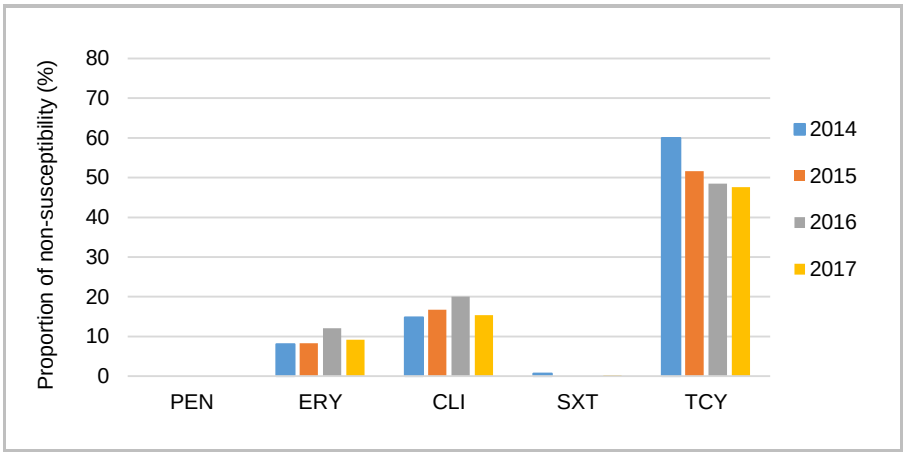

Figure 15. Antimicrobial resistance (%) in canine *S. canis* isolates in Finland in 2014-2015. Number of tested strains: 135 (2014), 157 (2015), 207 (2016), 293 (2017).
AMP, ampicillin; GEH, gentamicin high, SXT, trimethoprim-sulfamethoxazole (testing was started in 2015).

5.6 Other pathogens from dogs and cats

None of the canine or feline *E. faecalis* showed resistance to ampicillin. The proportion of isolates resistant to sulfonamide-trimethoprim, which can be a useful drug for the treatment of urinary tract infections caused by this organism, was nearly 13% (Figure 16).

All *Pasteurella canis* (n=130) and *Pasteurella multocida* (n=20) isolates from dogs were susceptible to ampicillin. Resistance to sulfonamide-trimethoprim was low since only one isolate per species showed resistance to this agent. Resistance to these agents was not observed in feline *Pasteurella* spp. (n=64) and *P. multocida* (n=33) isolates.

Twelve out of 46 feline *Staphylococcus felis* isolates were resistant to penicillin, but none to oxacillin or sulfonamide-trimethoprim. Macrolide-lincosamide resistance was 7% (3/46) in this species. All feline streptococci (n=31 of which 25 *S. canis*) were susceptible to penicillin and only one was resistant to sulfonamide-trimethoprim, while 8/31 (26%) were resistant to macrolides and 7/31 to clindamycin.

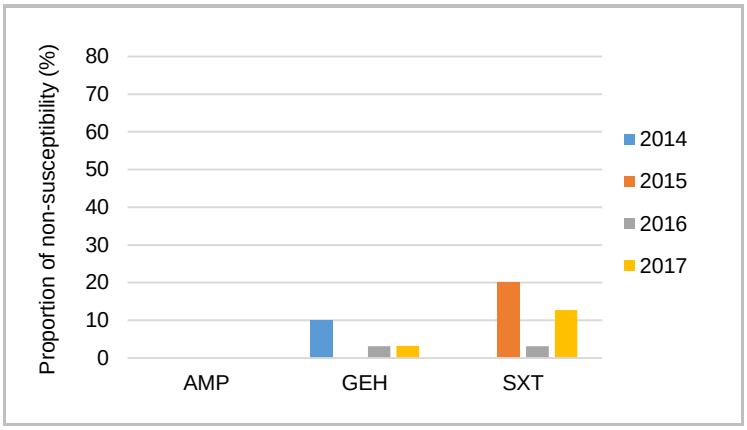

Figure 16. Antimicrobial resistance (%) in canine and feline urinary *E. faecalis* isolates in Finland in 2014-2015. Number of tested strains: 20 (2014), 24 (2015), 32 (2016), 63 (2017).
AMP, ampicillin; GEH, gentamicin high, SXT, trimethoprim-sulfamethoxazole (testing was started in 2015)

5.7 Other pathogens from horses

During the period of 2014-2017, 127 *Streptococcus equi* ssp. *zooepidemicus* isolates were tested. All the isolates were susceptible to penicillin while 7% (9/127) were resistant to sulfamethoxazole-trimethoprim. Although the number of isolates that were resistant to sulfamethoxazole-trimethoprim was still low, the increasing number of resistant isolates was a concerning signal. Therefore the development of sulfamethoxazole-trimethoprim resistance in equine streptococci should be carefully monitored.

For other equine pathogens the number of tested isolates was low. Of equine *S. aureus*, 16% (5/32) produced beta-lactamase thus being resistant to penicillin. MRSA was not observed and only two isolates showed decreased susceptibility to sulfamethoxazole-trimethoprim. Thirty-five percent of equine staphylococci produced beta-lactamase.

Of equine *Actinobacillus* spp. isolates, 6/28 (21%) had a high MIC to penicillin (MIC >32 mg/L) and 3/23 (13%) had MIC ≥4 mg/L to sulfamethoxazole-trimethoprim.

6 Antimicrobial resistance in indicator bacteria

Resistance among indicator bacteria such as commensal *E. coli* reflects the selection pressure caused by the use of antimicrobials in the population. Isolation of bacteria from the intestines of randomly selected animals at slaughter aims to detect the development of resistance in the bacterial population level in food animals (MARAN, 2008).

In this report, the results of indicator *E. coli* from slaughtered broilers (2016), cattle (2016) and pigs (2017) are presented. Details of sampling, isolation procedures and susceptibility testing are described in Appendix 3.

6.1 Indicator *E. coli* from broilers

The number of *E. coli* isolates included in the susceptibility testing was 184 from broilers. Resistance was low or rare against all of the examined antimicrobials (Table 21). The resistance was most common against tetracycline (10%). Four percent of the *E. coli* isolates were resistant to two antimicrobials. Resistance to three or more of the tested antimicrobials was found in 4% of the isolates. One *E. coli* was resistant to 3rd generation cephalosporins; the isolate was phenotypically a suspective AmpC-producer as it was also resistant to cefoxitin (MIC 16 mg/L).

In Finland, no antimicrobials to treat bacterial infections are used in broiler production flocks and it most likely reflects on the resistance situation. Also, resistance levels have only slightly varied in 2002-2016 and the overall situation is very favourable in commensal *E. coli* from broilers (Figure 17).

Table 21. Distribution of MICs for indicator *Escherichia coli* in broilers in 2016 (n=184).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	8.7	5.2-14.0							2.7	43.5	43.5	1.6				8.7				
Azithromycin	ND									2.2	47.3	46.7	3.8							
Cefotaxime	0.5	0-3.4					99.5			0.5										
Ceftazidime	0.5	0-3.4						99.5			0.5									
Chloramphenicol	0.0	0.0-2.5										97.8	2.2							
Ciprofloxacin	3.8	1.7-8.0	92.4	3.3	0.5	0.5	2.7	0.5												
Colistin	0.0	0.0-2.5							99.5	0.5										
Gentamicin	0.0	0.0-2.5						62.0	37.0	1.1										
Meropenem	0.0	0.0-2.5		100																
Nalidixic acid	3.3	1.4-7.3									96.7			0.5	1.1	1.1	0.5			
Sulfamethoxazole	5.4	2.8-10.0										47.3	44.0	2.2	1.1					5.4
Tetracycline	9.8	6.1-15.3								84.8	5.4				2.7	7.1				
Tigecycline	ND						84.8	15.2												
Trimethoprim	3.8	1.7-8.0					48.9	35.3	10.3	1.6					3.8					

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

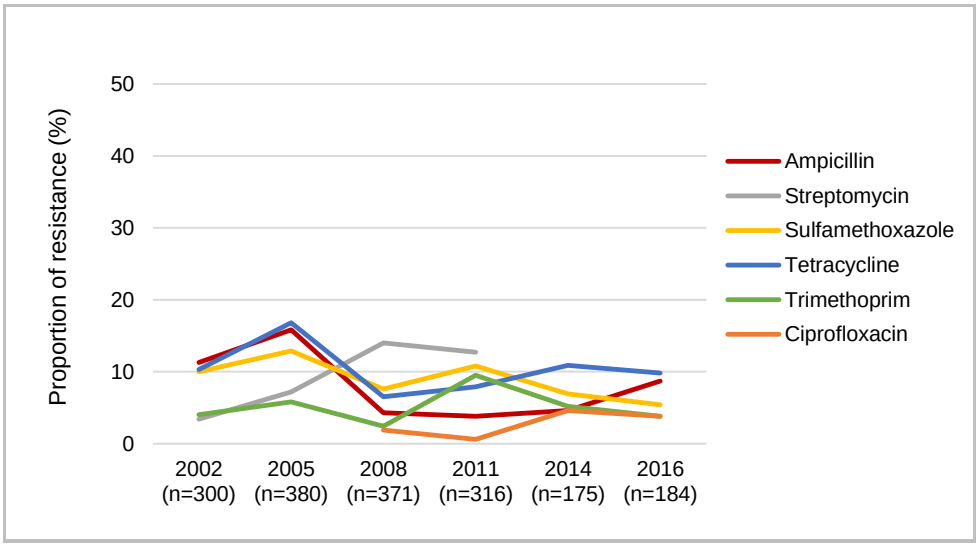

Figure 17. Resistance in indicator *E. coli* from broilers to selected antimicrobials in 2002-2016. Number of isolates tested each year in brackets.

6.2 Indicator *E. coli* from cattle

The number of *E. coli* isolates included in the susceptibility testing was 156. Resistance levels varied from rare to low among *E. coli* from cattle (Table 22). Only two isolates were multi-resistant. Resistance in indicator *E. coli* has been very low for many years (Figure 18) and the trend continues to be favourable also in 2016.

Table 22. Distribution of MICs for indicator *Escherichia coli* in cattle in 2016 (n=156).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	1.3	0.2-5.1							9.0	26.9	58.3	4.5				1.3				
Azithromycin	ND									2.6	37.8	57.7	1.9							
Cefotaxime	0.0	0.0-3.0					100													
Ceftazidime	0.0	0.0-3.0						100												
Chloramphenicol	0.6	0-4.0										97.4	1.9				0.6			
Ciprofloxacin	0.0	0.0-3.0	89.7	9.6	0.6															
Colistin	0.0	0.0-3.0							99.4	0.6										
Gentamicin	0.0	0.0-3.0						64.7	34.6	0.6										
Meropenem	0.0	0.0-3.0		99.4	0.6															
Nalidixic acid	0.0	0.0-3.0									98.1	1.9								
Sulfamethoxazole	1.9	0.5-5.9										49.4	44.2	4.5						1.9
Tetracycline	1.9	0.5-5.9								89.7	8.3				0.6	1.3				
Tigecycline	ND						76.3	23.7												
Trimethoprim	0.6	0-4.0					48.7	44.9	5.1	0.6					0.6					

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

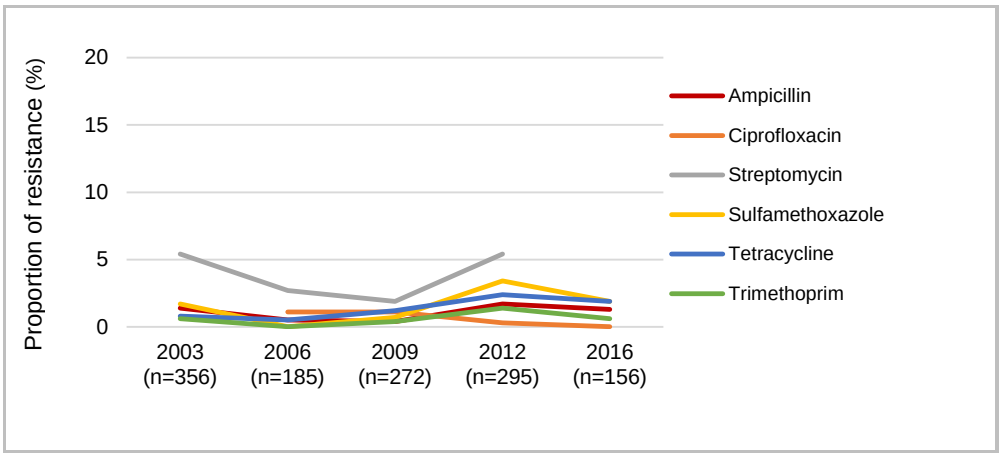

Figure 18. Resistance in indicator *E. coli* from cattle to selected antimicrobials in 2003-2016. Number of isolates tested each year in brackets.

6.3 Indicator *E. coli* from pigs

The number of *E. coli* isolates included in the susceptibility testing was 175. Resistance in *E. coli* varied from low to rare against many of the antimicrobials (Table 23). However, moderate resistance levels were found against three antimicrobials: tetracycline (18%), sulfamethoxazole (12%) and trimethoprim (11%). Tetracycline resistance was the most common observed resistance trait in *E. coli* – so the situation was the same as observed in the previous reports (FINRES-Vet reports 2009-2012 and 2013-2015). This can still be largely explained by the common use of tetracycline in pig production. Also, the combination of sulfonamides and trimethoprim is used widely which can explain the moderate resistance to those antimicrobials. Overall, resistance levels for tetracycline, sulfamethoxazole, trimethoprim, ampicillin and ciprofloxacin decreased from 2015 to 2017 although the longer trends in resistance to these antimicrobials seem to be quite stable (Figure 19).

Resistance to two antimicrobials was found in 4% of the *E. coli* isolates in 2017. Resistance to three and four antimicrobials was 6% and 4%, respectively. Resistance to fluoroquinolones and 3rd generation cephalosporins is still rare among commensal *E. coli* from pigs.

Table 23. Distribution of MICs for indicator *Escherichia coli* in pigs in 2017 (n=175).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg/L)																	
			0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
Ampicillin	8.6	5.1-14.0							1.7	41.7	45.1	2.9				8.6				
Azithromycin	ND									10.9	53.7	35.4								
Cefotaxime	0.0	0.0-2.7					100													
Ceftazidime	0.0	0.0-2.7						100												
Chloramphenicol	0.6	0-3.7										95.4	4.0		0.6					
Ciprofloxacin	0.0	0.0-2.7	94.9	4.6	0.6															
Colistin	0.0	0.0-2.7							99.4	0.6										
Gentamicin	0.0	0.0-2.7						73.1	24.0	2.9										
Meropenem	0.0	0.0-2.7		100																
Nalidixic acid	0.6	0-3.7									98.9	0.6		0.6						
Sulfamethoxazole	12.0	7.8-18.0										43.4	37.7	6.9						12.0
Tetracycline	18.3	13.0-25.0								81.7				0.6	3.4	14.3				
Tigecycline	ND						90.9	9.1												
Trimethoprim	11.4	7.3-17.3					58.3	29.7	0.6						11.4					

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

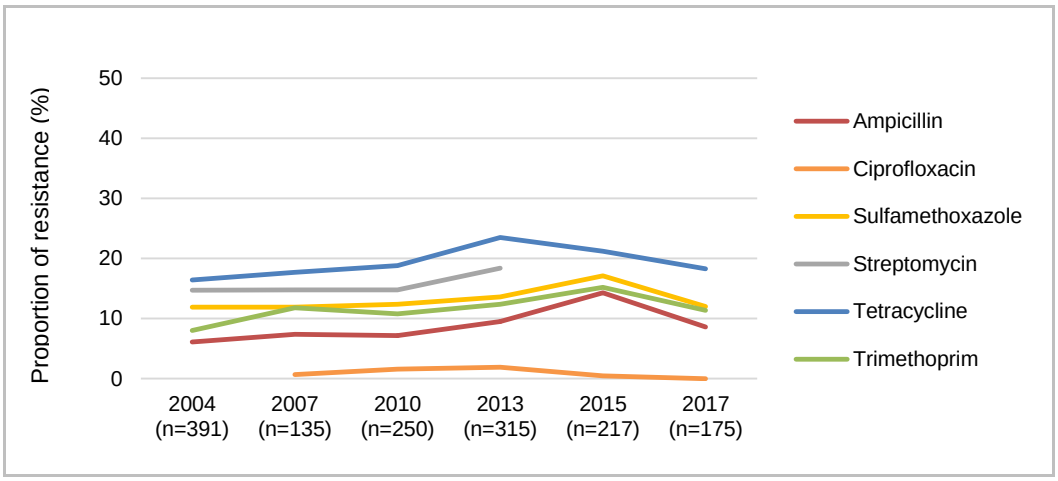

Figure 19. Resistance in indicator *E. coli* from pigs to selected antimicrobials in 2004-2017. Number of isolates tested each year in brackets.

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Appendix 1. Population statistics

The number of livestock and farms, and the production of meat and milk in Finland are presented in Tables 24-27. The displayed data originate from the statistics of Luke, the Natural Resources Institute Finland.

Table 24. Number of livestock in Finland in 1995, 2000, 2005 and 2010-2017.

	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Dairy cows	399	364	319	289	286	284	283	285	285	282	275
Suckling cows	29	28	35	55	57	58	57	58	59	59	60
Cattle > 1 year	298	300	277	278	273	268	271	268	264	258	261
Calves < 1 year	422	365	329	303	299	303	300	303	307	310	297
TOTAL, Cattle	1148	1057	959	926	914	913	912	914	915	909	893
Boars and sows	168	190	181	154	146	136	128	123	NA[2]	NA	NA
Pigs > 20 kg	757	694	769	804	797	779	815	760	NA	NA	NA
Piglets < 20 kg	476	412	451	409	392	375	365	362	NA	NA	NA
TOTAL, pigs	1400	1296	1401	1367	1335	1290	1308	1245	1243	1235	1136
Laying hens	4179	3110	3128	3394	3304	3173	3432	3645	3595	3599	3746
Chicks	1482	914	954	838	745	743	858	714	662	748	509
Broilers	4276	7918	5472	4616	5421	6038	6861	7341	7827	8272	8047
Turkeys	80	215	495	280	308	295	274	292	246	260	292
Other poultry[1]	315	395	477	459	457	512	555	584	597	566	543
TOTAL, poultry	10358	12570	10538	9587	10236	10761	11981	12577	12927	13445	13136

Number of cattle on 1.5. Number of pigs and poultry 1.4.
Number of poultry in 2016 not totally comparable with the previous years.

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

Table 25. Number of farms in Finland in 1995, 2000, 2005 and 2010-2017.

	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Cattle farms total	43095	30087	21493	15641	14919	14141	13416	12885	12389	11791	11175
Pig farms total	7304	4382	3086	2078	1917	1747	1637	1486	1337	1240	1102
Poultry farms total	7650	2636	1925	1304	1314	1155	1207	1299	1310	1300	1280

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

Table 26. The production of meat and fish (million kg) in Finland in 1995, 2000, 2005 and 2010-2017.

	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Beef[1]	96	90	85	82	83	80	80	82	86	86	85
Pork[1]	166	172	203	203	202	193	194	186	192	190	182
Poultry[1]	42	64	87	96	102	107	111	113	117	125	129
Total	306	328	376	383	387	382	387	383	397	403	397
Fish[2]	17	15	14	12	11	13	14	13	15	14	15

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

Table 27. The production of milk in Finland in 1995, 2000, 2005, 2010-2017.

	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Milk production; per animal (litres)	5982	6786	7505	7896	7859	7876	7977	8201	8323	8406	8534
Total milk production (million litres)	2396	2450	2362	2268	2234	2230	2260	2330	2365	2359	2336

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

Appendix 2. Data sources of veterinary antimicrobials

Data sources

The Finnish Medicines Agency monitors the sales of VMPs and obtains the sales data at package level from wholesalers. Sales of antimicrobial agents in medicated feed are monitored by the Finnish Food Authority Evira, which collects data from feed mills and other importers.

The sales statistics include products that have marketing authorization as well as those sold under special licence. Products authorised for human use but prescribed for animals are not included. It is unlikely that their absence skews the figures markedly as the proportion of human products used in companion animal practice account for 10-15 % of all antimicrobials used for these species (Rantala, 2003; Hölsö et. al., 2005).

Harmonised EU surveillance

Veterinary antimicrobial agents included in the data

The collection of sales data has been harmonised in accordance with the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project. The classification system was adjusted and the monitoring of locally administered products (administered to skin, eyes or ears) discontinued in 2009. The sales of local products are included in the table 1. (Total sales) for years 2003-2008 their amount being less than 200 kg a year.

Table 28. Categories and ATCvet codes of antimicrobial veterinary medicinal products to be included according to the ESVAC protocol (EMA/238630/2011).

Categories of veterinary antimicrobial agents	ATCvet codes
Antimicrobial agents for intestinal use	QA07AA; QA07AB
Antimicrobial agents for intrauterine use	QG01AA; QG01AE; QG01BA; QG01BE; QG51AA; QG51AG
Antimicrobial agents for systemic use	QJ01
Antimicrobial agents for intramammary use	QJ51
Antimicrobial agents used as antiparasitic agents	QP51AG

Conversion factors

Conversion factors according to ESVAC protocol have been applied for penicillin prodrugs since 2010. To enable comparisons, in FINRES-Vet 2010-2012 penicillin consumption was reported using both the old and the new method. After transitional period it was decided to give up old protocol and in this report only ESVAC harmonised results since 2010 are presented. Further information on the magnitude of changes in sales (kg active ingredient) due to changed protocol can be found in Appendix 2 of FINRES-Vet 2010-2012 report.

Appendix 3: Materials and methods, resistance monitoring

Sampling strategy

Zoonotic bacteria

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

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

C jejuni from cattle was isolated from the faecal samples (n=233) of healthy animals at slaughter. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. Each sample represented a herd. The sampling was evenly distributed between February and September. The slaughterhouses accounted approximately for 92% of the total number of slaughtered animals in Finland.

C. coli from pigs were isolated from the ceacal samples of healthy animals at slaughter. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. Each sample represented a farm. The sampling was evenly distributed between January and December in 2017. The slaughterhouses accounted approximately for 99% of the total number of slaughtered animals in Finland. From the total number of samples (307) available at the laboratory, thermophilic campylobacters were screened from 287 samples of which 279 represented a different epidemiological unit (a holding).

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

Animal pathogens

Clinical isolates originated from diagnostic submissions or postmortem examinations done in Evira laboratories. Accredited methodology was used in cultivation and identification. *Escherichia coli* was isolated from pigs with enteritis, the samples were taken from the contents of the gastrointestinal tract. All isolates examined were confirmed to be enterotoxigenic using PCR for toxin and fimbrial genes.

Staphylococcus aureus from broiler tenosynovitis cases were isolated from post-mortem samples submitted to Evira. All obtained *S. aureus* isolates were included from the study period. *A. pleuropneumoniae* isolates originate from post mortem investigations of lungs most likely from pigs with respiratory disease. Bovine respiratory pathogens were mostly from deep nasopharyngeal swabs from non-medicated calves suffering from acute respiratory disease. Also isolates from post mortem investigations of cattle lungs were included. *E. coli* isolates from broilers are from post mortem samples from parent or production pedigree, and isolated either from bone marrow or heart. *Brachyspira pilosicoli* isolates are from faecal samples of swine with diarrhea.

Antimicrobial resistance figures from companion animal pathogens were collected from the clinical microbiology laboratory of the Faculty of Veterinary Medicine, University of Helsinki. All isolates included in this report originated from clinical specimens. The data were available for the period of 2014-2017.

Screening of MRSA in pigs and pork

MRSA was screened from 61 pig slaughter batches between September 2016 and September 2017. Samples were collected from slaughterhouses (n=5) that accounted for 99% of all pigs slaughtered in Finland and the number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. The sampling was evenly distributed throughout the study period. From each slaughter batch, samples were taken from five healthy pigs. One isolate from each animal (if available) was selected for susceptibility testing and *spa* typing.

Altogether, 220 samples of packed fresh and chilled (not frozen) meat were collected at retail between January and October to represent the pork meat on market in Finland. Samples were randomly selected and collected from retail shops in three different NUTS-3 areas, covering approximately 46% of the Finnish population. Sampling was evenly distributed throughout the study period and allocated according to meat batches. The meat samples were sliced or diced and wrapped in vacuum or in a controlled atmosphere. Collected samples represented fresh pork meat of domestic (n=202) and non-domestic (n=18) origin. One isolate from each batch was selected for susceptibility testing and *spa* typing.

Screening of ESBL/AmpC/carbapenemase producing E. coli in meat

Randomly selected samples of packed fresh and chilled (not frozen) meat from broilers (n=309) in 2016, bovine animals (n=302) in 2017 and pigs (n=301) in 2017 were collected at retail between January and December each year. Sampling was evenly distributed throughout the year and allocated according to meat batches. Samples were collected from retail shops in three different NUTS-3 areas, covering approximately 46% of the Finnish population. The meat samples were sliced or diced and wrapped in vacuum or in a controlled atmosphere. Broiler meat samples were all of domestic origin. Of all pork samples, 287 and of all beef samples, 279 were of domestic origin. One isolate from each batch (if available) was selected for susceptibility testing.

Indicator bacteria and ESBL/AmpC/carbapenemase screening in food-producing animals

Indicator *E. coli* was isolated from broiler caeca and cattle faeces in 2016, and from pig caeca in 2017. From the same samples, the screening of ESBL/AmpC and carbapenemase producing *E. coli* was done. The samples from broilers (n=306) and pigs (n=307) originated from healthy animals at slaughter between January and

December. The samples from cattle (n=237) was collected from healthy animals at slaughter between February and September. From the total number of samples collected from pigs and cattle, 299 and 233 samples represented different epidemiological unit (a holding), respectively. The samplings were evenly distributed throughout the study periods. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. The broiler slaughterhouses accounted approximately for 98%, the pig slaughterhouses for 99%, and the cattle slaughterhouses for 92% of the total number of slaughtered animals in Finland.

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

Isolation and identification of bacteria

Zoonotic bacteria

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

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

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

Animal pathogens from food-producing animals

Isolation and identification of pathogens was performed by accredited conventional culture and biochemical/MALDI-TOF methods in Evira in Veterinary Bacteriology and Pathology Unit.

Animal pathogens from companion animals

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

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

The screening of ESBL/AmpC and carbapenemase producing *E. coli* from broilers, cattle and pigs was done from the same samples as the isolation of indicator *E. coli*. Also, meat samples from broilers, bovine animals and pigs were screened as part of the EU-wide monitoring based on Comission Decision 2013/652/EU. The EURL protocols were used for caecal samples from broilers (n=306) and pigs (n=299),

faecal samples from cattle (n=233 for ESBL/AmpC screening and n=204 for screening of carbapenemase producers), and the meat samples.

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).

Screening of MRSA in pigs and pork

Nasal swab samples from pigs or pork samples from retail stores were transported to the laboratory within one day. The temperature of the meat was measured at the laboratory at arrival.

MRSA was screened using selective enrichment broths and solid media. The method used was adapted from the EURL protocol for dust samples. Briefly, each nasal swab or 25 g of meat was suspended in 3 ml or 225 ml of Mueller Hinton (Difco™ Müller Hinton Broth, United States) broth with 6.5% NaCl (Merck, Germany), respectively, and incubated at 37°C for 16-20 h. Then 1 ml of the pre-enrichment broth was subsequently mixed with 9 ml of TSB broth (BBL™ TSB, United States) which included 75 mg/l aztreonam (Sigma-Aldrich, United States) and 3.5 mg/l cefoxitin (Sigma-Aldrich, United States). After an incubation at 37°C for for 16-20 h, 10 µl was spread on MRSA Select™ agar plates (BioRad, United States) and incubated at 37°C for 20-28 h. From each sample, one suspective pink colony was confirmed to *Staphylococcus aureus* using MALDI-TOF (Bruker, Germany). The presence of a *mecA* gene was confirmed with PCR using primers described by Murakami *et al*. (1991). All MRSA isolates were *spa* typed (Shopsin *et al*., 1999).

Indicator E. coli

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

Susceptibility testing

Bacteria from food-producing animals

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

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

Susceptibility testing was performed at Evira, Food and Feed Microbiology Research Unit and for *Brachyspira* spp. at Veterinary Bacteriology and Pathology Unit. The current 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 29). When available, clinical breakpoints of the current CLSI document (CLSI VET08, 2018) was used for the porcine and bovine respiratory pathogens. There are no standardised breakpoints approved for *Brachyspira* spp. from swine. Clinical cut-off values (Rønne at al. 1990) were applied to *B. pilosicoli* MICs.

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

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

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

Bacteria from companion animals

Susceptibility testing of bacteria isolated from companion animals was performed in in the clinical microbiology laboratory of the Faculty of Veterinary Medicine with a disk diffusion technique with an available CLSI standard (CLSI M31-A3 in 2011-2012 and CLSI VET01-A4 from 2012 onwards). For all data, clinical breakpoints of the latter standard (CLSI VET01-S2) was used to calculate non-susceptibility percentages. Resistance percentages include resistant and intermediate isolates. If veterinary breakpoints were not available, the breakpoints available in CLSI M100-S24 (2014) was used. An exceptions was the fucidic acid non-susceptibility breakpoint, which was ≤ 23 (FiRe-standard, version 6). Beta-lactamase activity was tested with Cefinase™ disks (Becton Dickinson, NJ, USA). *S. aureus* with oxacillin or cefoxitin MIC values >2 or >4, respectively, were tested for the presence of the *mecA* gene using primers described in Murakami *et al*. (1991).

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%

Quality assurance system

The Veterinary Bacteriology Unit of Evira participates in external quality assurance programmes for veterinary pathogens and in proficiency tests on isolation, identification and serotyping of Salmonella, and the Microbiology Research Unit participates in proficiency tests for antimicrobial susceptibility testing.

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

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

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

Appendix 4. *Salmonella* serovars isolated from Finnish food-producing animals in 2016-2017

Table 30. *Salmonella enterica* serovars isolated from the main food-producing animal species in Finland in 2016-2017.

Serotype	Year	N	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	2016	11	5	2	4	
	2017	11	4	4	3	
S. Enteritidis	2016	5	4		1	
	2017					
S. Derby	2016	2	1	1		
	2017	9		9		
S. Mbandaka	2016	4		4		
	2017	1		1		
S. Livingstone	2016					
	2017	3			3	
S. Coeln	2016					
	2017	2	2			
S. Konstanz	2016	1	1			
	2017	1	1			
S. Hessarek	2016	1	1			
	2017	1	1			
S. Poona	2016	1				1
	2017					
S. Tennessee	2016	1			1	
	2017					

Cover photos: Tarja Hietaranta/Evira

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Evira publications 5/2018
ISSN 1797-299X
ISBN 978-952-225-173-2 (pdf)

Evira