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FINRES-Vet 2013–2015

Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents

Fimea
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UNIVERSITY OF HELSINKI
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Description

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Authors	Suvi Nykäsenoja, Katariina Kivilahti-Mäntylä, Merja Rantala, Thomas Grönthal, Tarja Pohjanvirta, Satu Olkkola, Katariina Pekkanen, Maria Nummela, Henriette Helin-Soilevaara
Abstract	Changes in the number of food-producing animals during 2013–2015 were relatively small. Sales of veterinary antimicrobials continued to be moderate through the observation period. Overall sales show a decreasing trend, but sales of pharmaceutical forms for group treatment increased. Penicillin G continued to be the most sold veterinary antimicrobial despite the decreasing sales observed in this decade. Also sales of trimethoprim-sulphonamide combination administered orally decreased, contrary to sales of tetracyclines that increased. Proportion of highest priority critically important antimicrobials remained low with decreasing sales observed for 3rd generation cephalosporins and fluoroquinolones but increasing sales for macrolides. The occurence of antimicrobial resistance in bacteria isolated from animals and food has remained relatively good compared to the previous reporting periods. However, the development of resistance in certain bacteria are concerning so it is continuosly important to obey the Finnish recommendations for the use of antimicrobials in animals. Among Salmonella and Campylobacter, resistance levels were relatively low although fluoroquinolone resistance among Campylobacter isolates was relatively common. Among indicator bacteria, resistance was more common in *E. coli* isolates from pigs than from broilers. Multiresistance in *E. coli* strains isolated from cases of porcine enteritis is still common. Among isolates from bovine respiratory pathogens, resistance levels were relatively low or non-existent. Decresed susceptibility among *E. coli* from broiler colibacillosis cases was most common to tetracycline, fluoroquinolones and ampicillin. Instead, *S. aureus* from broiler tenosynovitis cases were susceptible to the tested antimicrobials. Antimicrobial resistance among animal pathogens isolated from companion animals was common. The proportion of ESBL producers of all *E. coli* isolated from dogs and cats has been quite stable during the last few years. ESBL/AmpC-producing *E. coli* was mostly encountered in broilers and seldom in pigs or pork. The occurrence of MRSA in pork was low.
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Tiivistelmä	Tuotantoeläinten määrässä ei tapahtunut suuria muutoksia. Eläinten mikrobilääkkeiden myynti pysyi seurantajakson aikana maltillisena. Kokonaismyynti väheni, mutta ryhmälääkkeiden myynti lisääntyi. Eniten myyty eläinten mikrobilääke oli penisilliini, vaikka sen myynti on tällä vuosikymmenellä vähentynyt selvästi. Myös suun kautta annosteltavaa sulfa-trimetopriimi-yhdistelmää myytiin selvästi aikaisempaa vähemmän, sen sijaan tetrasykliinien myynti kasvoi. Kriittisen tärkeiden mikrobilääkkeiden osuus pysyi vähäisenä. 3. polven kefalosporiinien ja fluorokinolonien myynti väheni, mutta makrolidien kasvoi. Eläimistä ja elintarvikkeista eristettyjen bakteerien mikrobilääkeresistenssi Suomessa on pysynyt kohtalaisen hyvänä edellisiin raportointikausiin verrattuna. Joillakin bakteereilla resistenssitilanteen kehittyminen on kuitenkin huolestuttavaa, joten on edelleen tärkeää noudattaa Suomessa eläimille annettuja mikrobilääkkeiden käyttösuosituksia. Kampylobakteereilla ja salmonelloilla resistenssiä todettiin pääasiassa vähän, vaikka resistenssi fluorokinoloneille oli kohtalaisen yleistä kampylobakteereilla vuosina 2013–2014. Sioista eristetyillä indikaattoribakteereilla (*E. coli*) todettiin enemmän resistenssiä kuin broilereista eristetyillä kannoilla. Sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla moniresistenssi oli edelleen yleistä. Nautojen hengitystietulehduksista eristetyillä bakteereilla resistenssiä esiintyi suhteellisen vähän tai ei ollenkaan. Broilereiden kolibasilloositapauksista eristetyillä *E. coli* -bakteereilla alentunutta herkkyyttä esiintyi eniten tetrasykliinille, fluorokinoloneille ja ampisilliinille. Sen sijaan broilereiden jännetuppitulehduksista eristetyistä *S. aureus* -bakteereista suurin osa oli herkkiä kaikille testatuille mikrobilääkkeille. Resistenssin esiintyminen harraste-eläimiltä eristetyillä tautia aiheuttavilla bakteereilla oli varsin yleistä. Koirista ja kissoista eristettyjen ESBL-kantojen osuus on pysynyt viime vuosina ennallaan. ESBL/AmpC-bakteereita esiintyi eniten broilereilla, mutta oli harvinaista sioilla ja sianlihassa. MRSA-bakteereita esiintyi sianlihassa hyvin vähän.
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Resumé	Det fanns inga stora förändringar i antalet husdjur. Försäljningen av antimikrobiella medel för behandling av djur förblev måttlig under uppföljningsperioden. Den totala försäljningen minskade, men försäljningen av preparater avsädda för gruppbehandling av djur ökade. Det mest sälda antimikrobiella för djur var penicillin, även om försäljningen har minskat tydligt detta decennium. Försäljningen av kombinationen sulfa-trimethoprim som administreras oralt var också klart lägre än tidigare, medan försäljningen av tetracykliner ökade. Andelen mikrobläkemedel som är kritiskt viktiga förblev låg. Försäljningen av tredje generationens cefalosporiner och fluorokinoloner minskade, men makrolider ökade. Resistenssituationen hos bakterien som har isolerats från djur och livsmedel av animaliskt ursprung har hållits relativt god i Finland jämfört med föregående rapporteringsperioder. Resistens hos vissa bakterier är dock bekymmersam varför det är fortfarande viktig att följa rekommendationerna för användning av antimicrobiella medel för djur i Finland. Hos salmonella och campylobacter konstaterades huvudsakligen litet resistens även om resistens mot fluorokinoloner hos kampylobakteriestammar var ganska vanligt år 2013–2014. Hos indikatorbakterier (*E. coli*) från svin konstaterades resistens mera hos stammar från broilrar. Multiresistens var fortvarande allmän hos *E. coli* som isolerats från tarminfektioner hos svin. Hos bakterien som isolerats från luftvägsinfektioner hos nötkreatur, resistens var låg eller den påvisades inte alls. Hos *E. coli* som isolerats från colibacillos reducerad känslighet var vanligaste mot tetracyklin, fluorokinoloner och ampicillin. Istället var majoriteten av *S. aureus* –bacterierna från tenosynovit känsliga mot alla testade antimicrobiella medel. Särskilt mycket resistens förekom hos bakteriestammar som orsakar sjukdomar hos hobby- och sällskapsdjur. ESBL-stammarnas andel av alla *E. coli* -bakterier isolerats från hundrar och katter har varit oförändrad under de senaste åren. Förekomsten av ESBL / AmpC-*E. coli* var den vanligaste hos broilers, men var sällsynt hos grisar och fläsk. Förekomsten av MRSA-bakterier var sällsynt i fläsk.
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Abstract

This report presents the results obtained in the FINRES-Vet monitoring in 2013–2015. However, to better discern long-term development, the tables and figures about consumption of antimicrobials and feed additives contain corresponding data starting from the year 2005. The report describes the occurrence of resistance in zoonotic bacteria 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 antibiotics and feed additives are reviewed.

The monitoring of antimicrobial resistance in bacteria isolated from food-producing animals and meat was harmonized in the European Union in 2014 (2013/652/EU). In 2015, the specific screenings of extended-spectrum beta-lactamase (ESBL/AmpC) producing bacteria was extended from production animals to cover meat as well. Besides the results obtained in mandatory monitoring, this report presents also antimicrobial resistance levels of bovine respiratory pathogens, *Staphylococcus aureus* from broiler tenosynovitis cases, *Escherichia coli* from porcine enteritis and broiler colibacillosis, as well as *Brachyspira* spp. from pigs. Moreover, results of the specific MRSA screening in pork meat, carried out in 2015, are presented.

Sales of veterinary antimicrobials in Finland

Changes in the number of food-producing animals during 2013–2015 were relatively small. A decreasing trend in overall sales of veterinary antimicrobials, in kg active ingredient, was observed from 2012 to 2015. Major changes were seen for the three most selling antimicrobials classes with sales of orally administered trimethoprim-sulphonamides and injectable penicillins decreasing. Sales of tetracyclines administered both orally and as injectables increased.

Of all antimicrobials sold, in 2015 53% were preparations for oral use, 45% injectables and 2% intrammammary preparations. The sales of pharmaceutical forms suitable for group treatment increased.

The proportion of the highest priority critically important antimicrobials remained very low. Marked decreases were noted for sales of 3rd generation cephalosporins and fluoroquinolones, but sale of macrolides increased.

Antimicrobial resistance in zoonotic bacteria

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. Furthermore, *Campylobacter* isolates from broilers, cattle and pigs are monitored in the FINRES-Vet programme.

Salmonella in food-producing animals and foods of animal origin is rare in Finland and mostly isolated in cattle. Majority of the *Salmonella* isolates were susceptible to the tested antimicrobials. However, resistant isolates were detected among cattle, pigs and laying hens. Multiresistance (resistance to ≥3 different antimicrobial classes) occurred in *S.* Typhimurium strains from cattle. Resistance occurred also among six *S.* Enteritidis strains isolated from food-producing animals in 2013–2015.

Since 2010, resistance to gentamycin and erythromycin has been rare in *Campylobacter jejuni* isolates from broilers; in 2013–2015 resistance to these antimicrobials was not detected. However, resistance to quinolones and tetracycline peaked in 2013–2014 for unknown reason. The highest numbers were found in 2014, when 25% of isolates were resistant to quinolones and 17% to tetracycline. In 2013, quinolone resistance in *Campylobacter* isolates from pigs has decreased slightly compared to year 2010. However, still almost one fifth of the *C. coli* isolates were resistant to quinolones in 2013.

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

The occurence of ESBL/AmpC-producing *E. coli* in pigs and broilers was low; the highest proportion of positive samples was 7% (broilers, 2014). In pigs, the majority of the isolates were AmpC-producers and in broilers nearly a half. Carbapenemase production was neither detected in food-producing animal nor meat. Of all analysed beef and pork meat samples, only one presumptive AmpC-producing *E. coli* was found in pork.

Specific MRSA screening in meat

The occurrence of methicillin-resistant *S. aureus* (MRSA) was monitored from fresh pork in 2015. Of the 303 pork samples analysed, MRSA was found in 9 (3%) samples. Two different *spa* types were detected, t034 (n=6) and t2741 (n=3), which both belong to the clonal complex (CC) 398 that is common among food-producing animals.

Antimicrobial resistance in animal pathogens from food-producing animals

As in previous years, resistance was commonly found in *E. coli* strains isolated from porcine enteritis cases. Resistance was most common against tetracycline, streptomycin and ciprofloxacin. Unlike in previous years, isolates resistant to 3rd generation cephalosporins with an AmpC phenotype were detected every year (2013–2015). Multiresistance was common; even resistance to six different antimicrobial classes was found. Resistance to colistin was not detected. Resistance levels have varied during the last decade but due to a low number of isolates tested each year, the trends cannot be reliably analysed.

Since 2015, bovine respiratory pathogens *Pasteurella multocida, Mannheimia haemolytica* and *Histophilus somni*, as well as porcine respiratory pathogen *Actinobacillus pleuropneumoniae* have all been tested using broth microdilution method. Therefore, distribution of MICs for these pathogens are only presented from year 2015. CLSI clinical breakpoints, when available, were applied. No resistance to the tested antimicrobials was seen among *A. pleuropneumoniae* isolates. However, 67% of the isolates were classified as intermediate against oxytetracycline. Among bovine respiratory pathogens, all *H. somni* isolates were susceptible. Oxytetracycline resistance was 4.4% and 8.6%, and penicillin resistance 1.5% and 5.7% in *P. multocida* and *M. haemolytica*, respectively.

Escherichia coli serotype O18 caused quite severe colibacillosis outbreaks in broiler farms in 2014. Serotype O78 was the main serotype seen in 2015 causing severe colibacillosis in all Nordic countries. Because of these epidemics, the number of tested isolates in 2014 and 2015 was exceptionally high. Colibacillosis is treated with antimicrobials only in parent flocks. No antimicrobials have been used in production flocks. Based on ECOFFs, resistance to tetracycline was most common (7.6-17.4%), although a decreasing trend from 2013 to 2015 was seen. Fluoroquinolone resistance appeared in 2014 (8%) and increased further the year after (17%). This peak might have been caused by a new line of parent birds imported to Finland. It is a well-known fact that *E. coli* clones are transmitted from parents to the next generation in broilers. A peak in resistance against 3rd generation cephalosporins was seen in 2014 (4.4% cefotaxime R and 5.9% ceftazidime R).

Most of the *S. aureus* strains isolated from broiler tenosynovitis cases were susceptible to the tested antimicrobials. MRSA was not detected.

There are no standardised breakpoints established for *Brachyspira* from swine. When epidemiological cut-off values established in Sweden (Pringle et al. 2012) were applied to MIC distributions of *B. hyodysenteriae*, decreased susceptibility to tiamulin was seen in 6% and to tylvalosin in 13% of the isolates. As a guide for the choice of antimicrobial for the treatment of spirochaetal diarrhoea, a clinical breakpoint for tiamulin of >2 mg/L and for tylosin of >16 mg/L are used in Sweden. With these breakpoints, 25 to 32% of *B. pilosicoli* isolates were resistant to tylosin, and no resistance to tiamulin was detected.

Antimicrobial resistance in animal pathogens from companion animals

Antimicrobial resistance statistics for companion animals (mainly dogs, 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 June 2011 to December 2015. Bacterial species included in this report were *Staphylococcus aureus* (dogs, cats and horses), *Staphylococcus pseudintermedius* (dogs and cats), *Escherichia coli* (dogs, cats and horses), and Group C streptococci (horses), *Actinobacillus* spp. (horses) and the *Klebsiella-Enterobacter-Serratia-Citrobacter*-group (KESC; horses).

S. aureus isolates from horses, dogs, and cats were collated. The level of antimicrobial resistance was low, except for penicillin to which 65% of the isolates were resistant. Equine *S. aureus* isolates were less frequently penicillinase positive than isolates from other species. Only a few MRSA isolates were observed.

Antimicrobial resistance among *S. pseudintermedius* isolates from dogs and cats was high (tetracycline, clindamycin, macrolides) to moderate (oxacillin, sulphonamide-trimethoprim) and remained stable over years. The proportion of MRSP among *S. pseudintermedius* isolates was 14% in 2015.

E. coli isolates from dogs and cats were frequently resistant to aminopenicillins (in 2015 nearly 50% of the isolates were resistant to ampicillin and 20% to amoxicillin-clavulanic acid). Nearly one fifth of the isolates were resistant to sulphonamide-trimethoprim and 14% to enrofloxacin. The proportion of ESBL *E. coli* was 2.5% and AmpC *E. coli* 4.5% in 2015. Among ESBL *E. coli* there were two carbapenemase positive isolates.

Antimicrobial resistance was high in *E. coli* and KESC isolates from horses. In *E. coli*, nearly 7% of isolates were ESBL producers while the respective proportion for KESC isolates was 35%. Of *Actinobacillus* spp., 15% had high MIC (>2) to penicillin and 9% had reduced susceptibility to sulphonamide-trimethoprim. Among Lancefield group C streptococci, resistance was rare (sulphonamide-trimethoprim) or non-existent (penicillin).

Antimicrobial resistance in indicator bacteria

In this report, the results of indicator *E. coli* from slaughtered pigs in 2013 and 2015, and from slaughtered broilers in 2014 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, streptomycin, sulfamethoxazole and trimethoprim. Minor increases in sulfamethoxazole and trimethoprim resistance levels and a decrease in tetracycline resistance level were observed during the reporting period from 2013 to 2015. Multiresistance occurred among *E. coli* isolates from pigs; the highest proportion of multiresistant isolates was 8%.

In broilers, resistance among *E. coli* was low or rare against most of the examined antimicrobials, only resistance against tetracycline exceeded 10%. Multiresistance was found in 5% of *E. coli* isolates.

Tiivistelmä

Tämä raportti kokoaa FINRES-Vet-seurannan tulokset vuosilta 2013–2015. Pitemmän aikavälin muutosten hahmottamiseksi raportin eläinlääkkeiden ja rehun lisäaineiden kulutustaulukot ja kaaviot sisältävät tiedot alkaen vuodesta 2005. Raportissa tarkastellaan mikrobilääkeresistenssin esiintymistä tuotantoeläimistä eristetyissä zoonoottisissa bakteereissa, tuotantoeläimistä eristetyissä indikaattoribakteereissa sekä tuotanto-, pien- ja harraste-eläimillä tautia aiheuttavista 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. Vuonna 2015 laajakirjoisia beetalaktamaaseja (ESBL/AmpC) tuottavien bakteerien seulontaa alettiin tehdä tuotantoeläinten lisäksi myös elintarvikkeista. EU-jäsenmaissa yhteisten, pakollisten seurantakohteiden lisäksi tässä raportissa esitellään myös ensimmäistä kertaa hengitystietulehduksia aiheuttavien bakteerien, broilerien jännetuppitulehduksista eristettyjen *Staphylococcus aureus* -bakteerien, broilerien nekroottisista suolistotulehduksista ja porsaiden suolistotulehduksista eristettyjen *Escherichia coli* -bakteerien sekä sioista eristettyjen brakyspirojen resistenssituloksia. Lisäksi raporttiin on koottu Suomessa vuonna 2015 toteutetun sianlihan MRSA-seurannan tulokset.

Eläinten mikrobilääkkeiden kulutus Suomessa

Tuotantoeläinten määrissä ei tapahtunut merkittäviä muutoksia vuosina 2013–2015. Eläinten mikrobilääkkeiden myynti (kg vaikuttavaa ainetta) väheni vuosina 2012–2015. Suurimmat muutokset koskivat eniten myytyjä lääkeryhmiä. Suun kautta annettavan sulfa-trimetopriimi-yhdistelmän ja injektiopenisilliinin myynti laski. Sen sijaan suun kautta sekä injektiona annettavien tetrasykliinien myynti lisääntyi.

Vuonna 2015 myydyistä eläinten mikrobilääkkeistä 53 % oli suun kautta annettavia valmisteita, 45 % injektiovalmisteita ja 2 % utareen sisäisesti annettavia valmisteita. Ryhmälääkintään tarkoitettujen valmisteiden myynti lisääntyi.

Kriittisen tärkeiksi luokiteltujen mikrobilääkkeiden osuus kokonaismyynnistä pysyi erittäin pienenä. Kolmannen polven kerfalosporiinien ja fluorokinolonien myynti väheni selvästi, mutta makrolidien myynti lisääntyi.

Zoonooseja aiheuttavien bakteerien resistenssi

FINRES-Vet-ohjelma kattaa kansallisessa salmonellavalvontaohjelmassa naudoista, sioista ja siipikarjasta eristetyt salmonellat sekä kotimaisista elintarvikkeista ja elintarvikealan toimijoiden omavalvonnassa eristetyt salmonellat. Lisäksi ohjelmassa seurataan broilereista, naudoista ja sioista eristettyjen kampylobakteerien resistenssitilannetta.

Tuotantoeläimistä eristetään vuosittain korkeintaan muutamia kymmeniä salmonelloja, pääasiassa naudoista. Tämä kuvastaa tartuntojen kansainvälisesti vertaillen erittäin alhaista tasoa. Resistenttejä *Salmonella*-kantoja todettiin sekä naudoilta, sioilta että munintakanoilta; suurin osa eristetyistä kannoista oli kuitenkin herkkiä. Nautojen *Salmonella enterica* serovaari Typhimurium -kannoilla todettiin myös moniresistenssiä eli resistenssiä kolmelle tai useammalle mikrobilääkeryhmälle. *S.* Enteritidis -kantoja eristettiin vuosina 2013–2015 kotimaisista tuotantoeläimistä vain kuusi, joista osalla todettiin resistenssiä.

Broilereista eristetyillä kampylobakteereilla on esiintynyt resistenssiä gentamisiinille ja erytromysiinille hyvin vähän; raportointijaksolla 2013–2015 ei todettu yhtään näille mikrobilääkkeille resistenttiä kantaa. Sen sijaan kinoloneille ja tetrasykliineille resistenttien kampylobakteerikantojen osuus nousi hetkellisesti vuosina 2013–2014; 25 % *C. jejuni* -kannoista oli resistenttejä siprofloksasiinille ja 17 % tetrasykliinille vuonna 2014. Syytä resistenttien kampylobakteerien hetkelliselle lisääntymiselle ei tiedetä. Sioista eristettyjen kampylobakteerien kinoloniresistenssi oli vähentynyt hieman vuoteen 2010 verrattuna, mutta edelleen lähes viidesosa *C. coli* -kannoista oli kinoloneille resistenttejä vuonna 2013.

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

Sioilla ja broilereilla laajakirjoisia beetalaktamaaseja (ESBL/AmpC) tuottavia *E. coli* -bakteereita esiintyi vähän, enimmillään 7 prosentissa tutkituista näytteistä (broilereilla vuonna 2014). Sioilla suurin osa eristetyistä kannoista oli AmpC-tuottajia ja broilereilla vajaa puolet. Karbapenemaasin tuottajia ei todettu tuotantoeläimillä eikä lihassa. Tutkituista sian- ja naudanlihanäytteistä ainoastaan yhdestä sianlihanäytteestä eristettiin AmpC *E. coli*.

Metisilliinille resistentti *Staphylococcus aureus* (MRSA) lihassa

MRSA-tilannetta kartoitettiin vuonna 2015 tuoreessa, maustamattomassa vähittäismyydyssä sianlihassa. Seulonnassa tutkittiin yhteensä 303 eri lihavalmiste-erää, joista yhdeksässä (3 %) todettiin MRSA-bakteeria. Todetut kannat olivat *spa*-tyyppejä t034 ja t2741, jotka kuuluvat tuotantoeläimillä yleisesti todettuun CC398-ryhmään.

Tuotantoeläinten taudinaiheuttajien resistenssi

Sikojen suolitulehduksista eristetyillä *E. coli* -bakteereilla resistenssiä esiintyi aiempien vuosien tapaan runsaasti. Edelleen eniten resistenssiä todettiin tetrasykliinille, streptomysiinille ja siprofloksasiinille. Aiemmista vuosista poiketen kaikkina tutkimusvuosina (2013–2015) eristettiin myös kolmannen polven kefalosporiineille resistenttejä *E. coli* -kantoja, joilla oli AmpC-fenotyyppi. Moniresistenssi oli

tavallista; tutkitut *E. coli* -kannat olivat enimmillään resistenttejä jopa kuudelle eri mikrobilääkeryhmälle. Kolistiiniresistenssiä ei todettu. Resistenssitilanne on vaihdellut kymmenen vuoden aikana jonkin verran, mutta eri vuosina havaituista resistenssitasojen eroista ei voida vetää erityisiä johtopäätöksiä vähäisen kantamäärän vuoksi.

Vuoden 2015 alusta nautojen hengitystiepatogeenien *Pasteurella multocida, Mannheimia haemolytica* ja *Histophilus somni*, sekä sikojen hengitystiepatogeenin *Actinobacillus pleuropneumoniae* mikrobilääkeherkkyyttä alettiin tutkimaan nestelaimennusmenetelmällä. Näiden patogeenien MIC-jakaumat esitetään siksi vain vuodelta 2015. Tulkinnassa on käytetty CLSI:n kliinisiä raja-arvoja aina kun sellainen on ollut saatavilla. *A. pleuropneumoniae* -kannat olivat herkkiä kaikille testatuille mikrobilääkkeille, samaten nautojen *H. somni* -kannat. Nautojen *P. multocida* -kannoissa resistenssiä oksitetrasykliinille esiintyi 4,4 % ja resistenttejä penisilliinille oli 1,5 % tutkituista kannoista. *M. haemolytica* -bakteerin osalta vastaavat luvut olivat 8,6 % ja 5,7 %.

Escherichia coli seroryhmä O18 aiheutti melko vakavia kolibasilloosipurkauksia broileritiloilla vuonna 2014. Vuonna 2015 seroryhmä O78 aiheutti erittäin vakavia koli-infektioita kaikissa Pohjoismaissa. Siksi vuosina 2014–2015 tutkittujen *E. coli* -kantojen määrä on poikkeuksellisen suuri. Tulkinnassa on käytetty epidemiologisia raja-arvoja. Tetrasykliiniresistenssi oli yleisin; sitä todettiin vuosittain 7,6 – 17,4 %. Kuitenkin trendi oli vuodesta 2013 vuoteen 2015 laskeva. Fluorokinoloniresistenssiä todettiin vuonna 2014 8 %:lla tutkituista kannoista ja se lisääntyi edelleen seuraavana vuonna ollen 17 %. Tämä saattaa olla seurausta uudesta maahantuodusta emolinjasta. Useat tutkimukset ovat osoittaneet että *E. coli* -kannat siirtyvät broilerituotannossa sukupolvelta toiselle. Kolmannen polven kefalosporiiniresistenssiä todettiin erityisesti vuonna 2014 (4,4 % kefotaksiimi R ja 5,9 % keftatsidiimi R).

Broilerien jännetuppitulehduksia aiheuttavista *S. aureus* -bakteereista suurin osa oli herkkiä kaikille testatuille mikrobilääkkeille. MRSA-kantoja ei todettu.

Sikojen *Brachyspira*-bakteereille ei ole olemassa standardisoituja hyväksyttyjä raja-arvoja. Sovellettaessa *B. hyodysenteriae* -aineistoon Ruotsissa asetettuja epidemiologisia raja-arvoja (Pringle ym., 2012) todettiin 6 %:lla kannoista alentunut herkkyys tiamuliinille ja 13,4 %:lla vastaavasti tylvalosiinille. Spiroketaaliripulin hoidossa Ruotsissa käytetään tiamuliinille kliinistä raja-arvoa >2 µg/ml ja tylosiinille arvoa >16 µg/ml. Näiden rajojen perusteella kaikki *B. pilosicoli* -kannat olivat herkkiä tiamuliinille ja 25–32 % vuosittain resistenttejä tylosiinille.

Seuraeläinten taudinaiheuttajien resistenssi

Harraste- ja seuraeläinten osalta resistenssiaineisto koottiin eläinlääketieteellisen tiedekunnan laboratoriossa Helsingin yliopistossa. Data on kerätty kesäkuun 2011 ja joulukuun 2015 välisenä ajanjaksona. Raportti sisältää resistenssitiedot seuraavista bakteereista: *S. aureus* (koirat, kissat, hevoset), *Staphylococcus pseudintermedius* (koirat, kissat), *E. coli* (koirat, kissat, hevoset), C-ryhmän streptokokit (hevoset), *Actinobacillus* spp. (hevoset) ja *Klebsiella-Enterobacter-Serratia-Citrobacter*-ryhmä (KESC; hevoset).

Resistenssi *S. aureus* -kannoilla oli vähäistä lukuun ottamatta penisilliiniresistenssiä, sillä 65 % kannoista tuotti beetalaktamaasia. Hevosten *S. aureus* -kannat tuottivat

harvemmin penisillinaasia kuin muiden eläinten. Vain muutama MRSA-löydös raportoitiin seuranta-ajalta.

Koirista ja kissoista eristetyillä *S. pseudintermedius* -kannoilla resistenssi oli hyvin yleistä tetrasykliinille, klindamysiinille ja makrolideille. Resistenssi oli myös yleistä oksasillinille ja sulfonamidi-trimetopriimille. Resistenssi pysyi melko tasaisena vuodesta toiseen. MRSP-bakteerien osuus oli 14 % vuonna 2015.

Kissojen ja koirien *E. coli* -bakteerit olivat usein resistenttejä ampisilliinille (lähes 50 % vuonna 2015) ja amoksisilliini-klavulaanihapolle (lähes 20 % vuonna 2015). Lähes joka viides kanta oli resistentti sulfonamidi-trimetopriimille ja 14 % enrofloksasiinille. ESBL-bakteerien osuus oli 2,5 % ja AmpC-bakteerien 4,5 % vuonna 2015. ESBL-osuudessa on mukana kaksi karbapenemaasia tuottavaa kantaa.

Hevosten *E. coli* and KESC bakteereissa resistenssi oli erittäin yleistä. *E. coli* bakteereista lähes 7 % oli ESBL-tuottajia, ja KESC-ryhmän bakteereista jopa 35 %. *Actinobacillus* spp. -kannoista oli 15 % penisilliinille resistenttejä (MIC >2 mg/l) ja 9 % oli herkkyydeltään heikentyneitä sulfonamidi-trimetopriimille. Ryhmän C-streptokokeissa resistenssi oli hyvin harvinaista, eikä penisilliiniresistenssiä esiintynyt.

Indikaattoribakteerien resistenssi

E. coli -kantoja kerättiin vuosina 2013 ja 2015 sioista sekä vuonna 2014 broilereista teurastuksen yhteydessä otetuista näytteistä. Sioista eristetyillä *E. coli* -kannoilla resistenssi vaihteli harvinaisesta kohtuulliseen. Eniten resistenssiä esiintyi tetrasykliinille, streptomysiinille, sulfametoksatsolille ja trimetopriimille, joista resistenssi kahdelle jälkimmäiselle nousi raportointijaksolla vuodesta 2013 vuoteen 2015. Sen sijaan tetrasykliinille resistenttien *E. coli* -kantojen osuus laski hieman raportointijaksolla. Pieni osa – korkeintaan 8 % – *E. coli* -kannoista oli moniresistenttejä.

Broilereista eristetyillä *E. coli* -kannoilla resistenssiä esiintyi yleisesti ottaen hyvin vähän, ainoastaan tetrasykliiniresistenssi nousi yli 10 prosentin. Moniresistenssiä todettiin viidellä prosentilla tutkituista *E. coli* -kannoista.

Resumé

Denna rapport sammanfattar resultaten från resistensuppföljningsprogrammet FINRES-Vet åren 2013–2015. För att ge en bild av förändringarna på längre sikt, ingår uppgifter om konsumtionen av de flesta veterinärmedicinska läkemedel och fodertillsatser i rapportens tabeller och scheman från och med år 2006. I rapporten granskas förekomsten av antibiotikaresistens hos zoonotiska bakterier som isolerats från produktionsdjur, hos indikatorbakterier som isolerats från produktionsdjur och hos bakterier som orsakar sjukdom hos produktionsdjur, smådjur och hobbydjur. I rapporten presenteras också ändringarna som skett i informationen om försäljningen av veterinärmedicinska läkemedel och i livsmedelsproducerande djurpopulationen 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). År 2015 började man göra screening av bakterier som producerar betalaktamaser med utvidgat spektrum inte enbart hos livsmedelsproducerande djur utan också i livsmedel. Utöver de i EU-medlemsstaterna gemensamma, obligatoriska uppföljningsobjekten presenteras i denna rapport också för första gången resistensresultaten för bakterier som orsakar luftvägsinfektioner, *Staphylococcus aureus* -bakterier som isolerats från inflammationer i senskidan hos broilerkycklingar, *Escherichia coli* -bakterier som isolerats från kolibacillos hos broilerkycklingar och inflammationer i tarmkanalen hos grisar. I rapporten har också sammanförts resultaten av MRSA-uppföljningen som genomfördes i Finland år 2015.

Konsumtionen av antimikrobiella läkemedel för djur i Finland

I antalen livsmedelsproducerande djur skedde inga betydande förändringar åren 2013–2015. Försäljningen av antimikrobiella läkemedel för djur (kg aktiv substans) minskade åren 2012–2015. De största förändringarna gällde de mest sålda läkemedelsgrupperna. Försäljningen av kombinationen sulfa-trimetoprim som administreras oralt och penicillin som administreras i form av injektion sjönk. Däremot ökade försäljningen av tetracykliner som administreras både oralt och i form av injektion.

År 2015 administrerades 53 % av mikrobläkemedel för djur oralt och andelen av läkemedel i form av injektion var 45 % och andelen av intramammära preparat 2 % av totalförbrukning. Försäljningen av preparat avsedda för gruppmedicinering ökade. Andelen av kritiskt viktiga mikrobläkemedel av den totala försäljningen förblev liten. Försäljningen av tredje generationens cefalosporiner och fluorokinoloner minskade tydligt, men försäljningen av makrolider ökade.

Resistensen hos bakterier som orsakar zoonoser

Programmet FINRES-Vet täcker inom ramen för det nationella programmet för salmonellakontroll salmonella som isolerats från nötkreatur, svin och fjäderfä, samt salmonella som isolerats från inhemska livsmedel och sådana som isolerats inom livsmedelsföretagarnas egenkontroll. I programmet uppföljs därtill resistensläget hos campylobacter som har isolerats från broilerkycklingar, nötkreatur och svin.

Från livsmedelsproducerande djur isoleras årligen högst några tiotal salmonella, huvudsakligen från nötkreatur. Detta reflekterar en mycket låg nivå av infektioner i internationell jämförelse. Resistenta *Salmonella*-stammar konstaterades hos såväl nötkreatur som svin och värphöns: merparten av de isolerade stammarna var ändå känsliga. Hos *Salmonella enterica* serovar Typhimurium -stammarna konstaterades också multiresistens dvs. resistens mot tre eller flera grupper antimikrobiella läkemedel. Av *S.* Enteritidis -stammarna isolerades åren 2013–2015 från inhemska produktionsdjur endast sex stammar och hos en del av dessa konstaterades resistens.

Hos campylobacter som isolerats från broilerkycklingar har förekommit mycket liten resistens mot gentamicin och erytromycin; under rapporteringsperioden 2013–2015 konstaterades inte en enda stam som var resistent mot dessa antimikrobiella läkemedel. Istället ökade resistensen mot kinoloner och tetracyklin hos campylobacter åren 2013–2014; 25 % av de *C. jejuni* stammarna var resistenta mot ciprofloxacin och 17 % mot tetracyklin år 2014. Orsaken till att de resistenta campylobacterna tillfälligt ökade är inte känd. Kinolonresistensen hos campylobacter som isolerats från svin hade minskat i jämförelse med året 2010, men fortsättningsvis var en femtedel av stammarna resistenta mot kinoloner år 2013.

Screeningen 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 betalaktamas med utvidgat spectrum (ESBL/AmpC) var låg hos svin och broilerkycklingar. Som mest konstaterades sådana bakterier i 7 procent av de undersökta proverna (hos broilerkycklingar år 2014). Hos svin var en del av de isolerade stammarna AmpC-producenter och hos broilerkycklingarna cirka hälften. Karbapenemasproducerande *E. coli* påvisades inte hos livsmedelsproducerande djur eller kött. Av proverna av griskött och nötkött påvisades AmpC *E. coli* bakterien endast i ett prov av griskött.

Meticillinresistent *Staphylococcus aureus* (MRSA) i kött

År 2015 utreddes förekomsten av MRSA i färskt griskött som hade samlats in i detaljhandelsledet. Totalt 303 prover av griskött undersöktes och i nio (3 %) av proverna konstaterades MRSA. MRSA-stammarna var av *spa* typerna t034 och t2741, som hör till den hos livsmedelsproducerande djur allmänt konstaterade CC398-gruppen.

Resistensen hos bakterier som orsakar sjukdomar hos livsmedelsproducerande djur

Hos *E. coli* -bakterier som isolerats från inflammationer i tarmkanalen hos svin förekom rikligt med resistens. Fortsättningsvis konstaterades mest resistens mot tetracyklin, streptomycin och ciprofloxacin. Till skillnad från tidigare år isolerades

alla undersökningsår (2013–2015) också tredje generationens kefalosporinresistenta *E. coli* -stammar som hade AmpC-fenotypen. Multiresistens var allmän; de undersökta *E. coli* -stammarna var mest resistenta mot upp till sex olika grupper antimikrobiella läkemedel. Resistens mot colistin påvisades inte. Förekomsten av resisten har varierat något under de senaste tio åren, men på grund av det låga antalet stammar kan man ännu inte dra några specifika slutsatser om skillnaderna mellan de observerade resistensnivåerna under olika år.

Sedan början av år 2015 har antibiotikakänsligheten hos luftvägspatogenerna *Pasteurella multocida, Mannheimia haemolytica* och *Histophilus somni* hos nötkreatur och luftvägspatogenen *Actinobacillus pleuropneumoniae* hos svin undersökts med den buljong spädningsmetoden. Dessa patogeners MIC-fördelningar presenteras därför endast för året 2015. Vid tolkning har använts kliniska gränsvärden av CLSI alltid då ett sådant varit tillgängligt. *A. pleuropneumoniae* -stammarna var känsliga för alla testade antimikrobiella läkemedel, så också *H. somni* -stammarna hos nötkreatur. Hos *P. multocida* -stammarna hos nötkreatur förekom resistens mot oxitetracyklin hos 4,4 % och resistens mot penicillin hos 1,5 % av de undersökta stammarna. För *M. haemolytica* -bakteriens del var motsvarande tal 8,6 % och 5,7 %.

Escherichia coli serogrupp O18 orsakade rätt allvarliga kolibacillosutbrott på gårdar med broilerkycklingar år 2014. År 2015 orsakade serogrupp O78 mycket allvarliga koliinfektioner i alla nordiska länder. Därför är antalet *E. coli* -stammar som undersöktes åren 2014–2015 exceptionellt stort. Vid tolkning har använts epidemiologiska gränsvärden. Tetracyklinresistens var vanligast; sådan konstaterades årligen hos 7,6 – 17,4 % av stammarna. Trenden från året 2013 till året 2015 är ändå sjunkande. Fluorokinolonresistens konstaterades år 2014 hos 8 % av de undersökta stammarna och den fortsatte öka året därpå till 16,7 %. Det kan vara en följd av en ny importerad moderlinje. Flera undersökningar har visat att *E. coli* -stammarna i broilerkycklingsproduktionen överförs från en generation till en annan. Tredje generationens kefalosporinresistens konstaterades speciellt år 2014 (4,4 % mot cefotaxime och 5,9 % mot ceftazidime).

Merparten av *S. aureus* -bakterierna som orsakar inflammationer i senskidan hos broilerkycklingar var känsliga mot alla testade antimikrobiella läkemedel. MRSA-stammar påvisades inte.

För *Brachyspira*-bakterierna hos svin finns inte några standardiserade godkända gränsvärden. Då de epidemiologiska gränsvärdena (Pringle etc. 2012) som fastställts i Sverige tillämpades på *B. hyodysenteriae* -materialet konstaterades att 6 % av stammarna hade en nedsatt känslighet mot tiamulin och 13,4 % av stammarna mot tylvalosin. Vid behandling av spiroketaldiarré används i Sverige för tiamulin och tylosin de kliniska gränsvärdena >2 µg/ml och >16 µg/ml. På basen av dessa gränsvärden var alla *B. pilosicoli* -stammar känsliga mot tiamulin och 25-32 % årligen resistenta mot tylosin.

Resistensen hos bakterier som orsakar sjukdomar hos sällskapsdjur

Materialet om resistens hos hobby- och sällskapsdjur insamlades av den veterinärmedicinska fakultetens laboratorium vid Helsingfors universitet. Data samlades in mellan juni 2011 och december 2015. I rapporten ingår resistensinformation om följande bakterier: *S. aureus* (hundar, katter, hästar), *Staphylococcus pseudintermedius* (hundar, katter), *E. coli* (hundar, katter, hästar), C-gruppens streptokocker (hästar),

Actinobacillus spp. (hästar) och gruppen *Klebsiella-Enterobacter-Serratia-Citrobacter* (KESC; hästar).

Hos *S. aureus* -stammarna var resistensen blygsam med undantag för penicillinresistensen, eftersom 65 % av stammarna producerade betalaktamas. *S. aureus* -stammarna hos hästar producerade mer sällan penicillinas än hos andra djur. Endast några få MRSA-fynd inrapporterades under uppföljningstiden.

Hos *S. pseudintermedius* -bakterier som isolerats från hundar och katter förekom särskilt mycket resistens mot tetracyklin, klindamycin och makrolider. Resistens var allmän också mot oxacilin och kombinationen sulfonamid-trimetoprim. Resistensen höll sig rätt jämn från ett år till ett annat. År 2015 var andelen MRSP-bakterier 14 %.

Hos *E. coli* -bakterier som isolerats från hundar och katter påvisades resistens främst mot ampicillin (nästan 50 % år 2015) och amoxicillin-klavulansyra (nästan 20 % år 2015). Nästan femtedel av alla *E. coli* var resistenta mot kombinationen sulfonamid-trimetoprim och 14 % mot enrofloxacin. År 2015 var andelen ESBL-bakterier 2,5 % och andelen AmpC-bakterier 4,5 %. I ESBL-delen ingår två karbapenem-producerande stammar.

Resistens var också mycket allmän hos *E. coli* och KESC-bakterier som isolerats från hästar. Av *E. coli* -bakterierna var inemot 7 % sådana som producerar ESBL, av bakterierna i KESC-gruppen hela 35 %. Av *Actinobacillus* spp. -stammarna var 15 % resistenta mot penicillin (MIC >2 mg/l) och 9 % hade nedsatt känslighet mot sulfonamid-trimetoprim. Hos gruppen C-streptokocker var resistens mycket sällsynt och penicillinresistens förekom inte alls.

Resistensen hos indikatorbakterier

Stammar av *Escherichia coli* insamlades år 2013 och 2015 från svin, och 2014 från broilerkycklingar av prover som tagits i samband med slakt. Hos *E. coli* -stammarna som isolerats från svin varierade resistensen från sällsynt till måttlig. Mest resistens förekom mot tetracyklin, streptomycin, sulfametoxazol och trimetoprim, En liten del – högst 8 % – av *E. coli* -stammarna var multiresistenta.

Resistens hos stammar av *E. coli* som isolerats från broilerkycklingar var I allmänhet sällsynt, endast resistensen mot tetracyklin var över 10 %. Multiresistens konstaterades hos 5 % av de undersökta *E. coli* -stammarna.

Contents

Introduction

In the FINRES-Vet programme, the antimicrobial resistance in zoonotic and indicator bacteria is monitored, as required by the Zoonosis Directive (2003/99/EC) and from 2014, the Commission Implementing Decision 2013/652/EU, and as decided at the national level. Furthermore, antimicrobial resistance is monitored in certain animal pathogens. In this report, more data on animal pathogens has been included compared to the previous FINRES-Vet reports.

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 resistance to antimicrobial agents in 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 (from 2002) have presented an overall favourable resistance situation among bacteria isolated from food-producing 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, especially from companion animals is of growing concern indicating that there is a need to further emphasize the prudent use of antimicrobials. Recommendations for antimicrobial usage in major infectious diseases of animals have been established to promote prudent use. These recommendations (in Finnish and Swedish) have been updated in 2016 and can be found in the internet site of Evira

[https://www.evira.fi/tietoa-evirasta/julkaisut/elaimet/oppaat/mikrobilaakkeiden-kayttosuositukset-elainten-tarkeimpiin-tulehdus--ja-tartuntatauteihin/]

This is the sixth FINRES-Vet report including data from the years 2013–2015. During this period, indicator bacteria (*E. coli*) has been collected from broilers and pigs. Also, the results of commensal *E. coli* are compared with the resistance levels in previous years to better understand the development of resistance in a longer time-frame. Zoonotic bacteria obtained for analysis are *Salmonella* and *Campylobacter*. Animal pathogens included in the report are *Escherichia coli* from pigs (from diarrhea cases), broilers (from colibacillosis cases) and companion animals, *Staphylococcus pseudintermedius* and *Staphylococcus aureus* from companion animals, and pathogens causing respiratory diseases in pigs and cattle, as well as *Brachyspira* spp. from pigs, and *Actinobacillus* spp. and group *C streptococcus* from horses. Also, the results of the specific monitorings 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 Faculty of Veterinary Medicine (University of Helsinki) provides antimicrobial susceptibility data from small animals and horses.

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

1.1 Changes in animal population

Changes in number of food producing animals during 2013–2015 were relatively small. The number of cattle has slightly decreased. However, the number of suckler cows shows a little increase. The total number of pigs has been quite constant during the last 10 years though the number of pig farms is halved during the same period. The number of poultry shows an increase especially due to rise in the number of broilers. Details on the number of holdings as well as on live and slaughtered animals 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, small amounts of antimicrobials are imported as medicated feed. The data on volume is collected from feed importers. The sales statistics are expressed as weight (kg active ingredient) sold. 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 1.

Majority of the veterinary medicinal products are used to treat several 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 levels of sales, expressed in kg, are foremost compared to sales of the same class over a longer time.

1.2.1 Overall sales of veterinary antimicrobial agents

During the reporting period the overall sales decreased by 7% compared to 2012 and were 12 300 kg in 2015 (Table 1, Figure 1). Penicillin G continued to be the most sold antimicrobial accounting for 35% of the overall sales in 2015. Combinations of trimethoprim and sulphonamides were the second most used antimicrobials (20%) and tetracyclines the third (18%). Altogether, these three antimicrobial classes accounted for 74% of the overall sales of veterinary antimicrobials in 2015.

Table 1. Overall sales of veterinary antimicrobials in Finland 2001, 2005–2015, kg active ingredient

	2001	2005	2006	2007	2008	2009		2010	2011	2012	2013	2014	2015
Tetracyclines, doxycyclin[1]	**1 937**	**1 445**	**1 320**	**1 705**	**3 140**	**2 284**		**1 728**	**1 838**	**1 759**	**2 389**	**2 576**	**2 250**
Amphenicols[2]						**59**		**59**	**124**	**61**	**121**	**84**	**80**
Betalactams (penicillins)								**6 593**	**6 406**	**6 223**	**6 116**	**5 967**	**5 896**
Penicillin G	*6 235*	*6 803*	*6 905*	*7 512*	*7 740*	*7 753*		*5 162*	*5 010*	*4 784*	*4 721*	*4 502*	*4 332*
Aminopenicillins	*532*	*958*	*846*	*1 057*	*1 178*	*1 256*		*1 317*	*1 284*	*1 342*	*1 314*	*1 374*	*1 498*
Cloxacillin	*149*	*132*	*109*	*96*	*97*	*113*		*114*	*112*	*97*	*82*	*91*	*65*
Cephalosporins	**1 153**	**1 000**	**1 004**	**1 030**	**1 027**	**987**		**911**	**1 064**	**917**	**802**	**760**	**613**
1st gen. cephalosporins						*985*		*906*	*1 056*	*902*	*793*	*753*	*605*
3rd gen. cephalosporins						*2*		*5*	*9*	*15*	*8*	*8*	*7*
Sulphonamides and trimetoprim	**2 490**	**2 438**	**2 946**	**2 655**	**2 933**	**3 165**		**3 274**	**3 045**	**3 149**	**3 129**	**2 893**	**2 445**
Sulphonamides						*2 637*		*2 728*	*2 537*	*2 624*	*2 607*	*2 410*	*2 037*
Trimetoprim						*527*		*546*	*508*	*525*	*522*	*483*	*408*
Macrolides, lincosamides	**492**	**393**	**619**	**752**	**847**	**594**		**774**	**696**	**755**	**611**	**711**	**760**
Macrolides						*429*		*572*	*532*	*575*	*456*	*521*	*596*
Lincosamides						*165*		*202*	*164*	*179*	*155*	*189*	*165*
Aminoglycosides	**632**	**238**	**225**	**180**	**170**	**179**		**166**	**128**	**108**	**103**	**101**	**93**
Quinolones						**97**		**96**	**102**	**107**	**105**	**113**	**94**
Fluoroquinolones	*101*	*90*	*81*	*88*	*90*	*97*		*96*	*102*	*107*	*105*	*113*	*94*
Other Quinolones (Oxolinic acid)						*0*		*0*	*0*	*0*	*0*	*0*	*0*
Polymyxins[2]						**0**		**0**	**0**	**0**	**0**	**0**	**0**
Pleuromutilins[2]						**80**		**48**	**73**	**66**	**43**	**44**	**30**
Others[2]	**103**	**112**	**74**	**80**	**120**	**-**		**-**	**-**	**-**	**-**	**-**	**-**
Total[3]	**13 824**	**13 609**	**14 129**	**15 155**	**17 342**	**16 566**		**13 651**	**13 475**	**13 144**	**13 419**	**13 250**	**12 262**

ESVAC harmonised sales since 2010

[1]2006–2008 sales of tetracycline in local preparations included.
[2]Before 2009 amphenicols, polymyxins and pleuromutilins were included in 'Others'
[3]Sales of locally administered products is included for years 2001–2008 in the table overall sales (less than 200 kg/year)

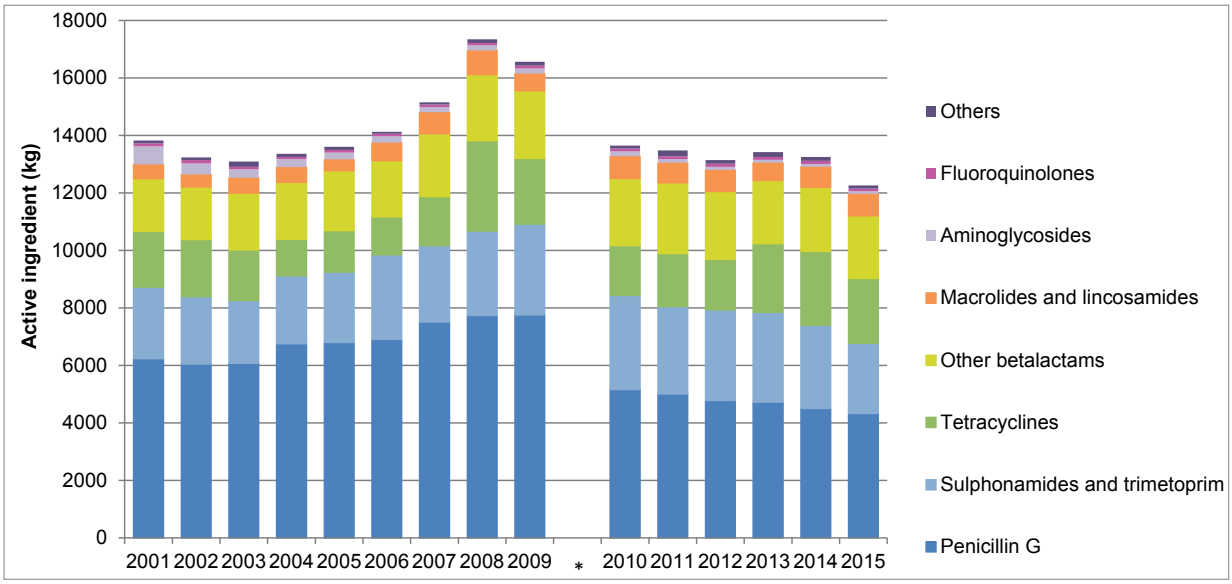


Figure 1. *Overall sales of veterinary antimicrobials (kg active ingredient). *ESVAC harmonised sales since 2010. Other betalactams: aminopenicillins, cephalosporins and cloxacillin. Others: amphemicols, pleuromutilins and polymyxins.*

1.2.1.1 Sales in relation to the production animal population

The sales expressed in units of weight do not reflect the possible changes in animal populations. In order to normalize the sales data for the population of food-producing animals that could be subjected to treatment with antimicrobial agents, a population correction unit (PCU) has been developed as a proxy for the size of the population within the ESVAC project (European Surveillance of Veterinary Antimicrobial Consumption). Detailed information how PCU is calculated can be seen in Appendix 2 of the first ESVAC report (EMA 2011).

PCU corrected sales in Finland have remained stable during 2011–2015 (21.9-21.8-22.4-22.3-20.4 mg/PCU) (EMA/ESVAC 2017). As PCU includes only data on food-producing animals, the sales of antimicrobial tablets which are almost solely used for companion animals, are excluded from the ESVAC calculations. Sales of antimicrobial tablets in 2010–2014 were approximately 2 tns/year (equivalent to 13-14% of the total kg-sales). In 2015, sales of tablets decreased to 1.7 tns (EMA 2017).

1.2.2 Injectable antimicrobial products

Approximately 6% less injectables were sold in 2015 compared to 2012 (Table 2). The change is mainly due to decreased sales of penicillin G which has continued through the decade. Penicillin is by far the most used injectable though its proportion has somewhat decreased in recent years (71% of injectables in 2015). Tetracyclines continued to be the second most used injectables, their proportion being approximately 11% of all injectables and aminopenicillins the third (8%) in 2015.

In 2015, shortage of certified starting material caused a major disturbance in the availability of injectable benzylpenicillin products. Special arrangements including provisional prudent use guidance to regulate the availability of benzylpenicillin to the most important indications was imposed. Antimicrobial classes recommended for compensation of benzylpenicillin included tetracyclines, aminopenicillins and trimethoprim and sulphonamides. Sales of all these classes used as injections increased from 2014 to 2015.

For details in sales of injectable highest priority critically important antimicrobials see section 1.2.5.

Table 2. Sales of injectable veterinary antimicrobials in Finland 2001, 2005–2015, kg active ingredient

Injectables	2001	2005	2006	2007	2008	2009		2010	2011	2012	2013	2014	2015
Tetracyclines, doxycyclin	**196**	**312**	**288**	**418**	**442**	**470**		**527**	**515**	**521**	**558**	**552**	**640**
Amphenicols	**0**	**0**	**0**	**0**	**0**	**0**		**0**	**12**	**13**	**26**	**17**	**6**
Betalactams (penicillins)								**5 462**	**5 253**	**4 986**	**4 920**	**4 659**	**4 520**
Penicillin G	*5 981*	*6 597*	*6 739*	*7 339*	*7 552*	*7 551*		*5 023*	*4 849*	*4 552*	*4 542*	*4 243*	*4 047*
Aminopenicillins	*76*	*236*	*170*	*358*	*410*	*413*		*440*	*404*	*434*	*379*	*416*	*473*
Cephalosporins[1]			**1**	**4**	**4**	**4**		**5**	**9**	**15**	**9**	**8**	**7**
1st gen. cephalosporins						*1*		*0*	*0*	*0*	*0*	*0*	*0*
3rd gen. cephalosporins						*2*		*5*	*9*	*15*	*8*	*8*	*7*
Sulphonamides and trimetoprim	**599**	**463**	**457**	**420**	**415**	**370**		**329**	**297**	**360**	**344**	**358**	**373**
Sulphonamides						*308*		*274*	*248*	*300*	*287*	*298*	*311*
Trimetoprim						*62*		*55*	*50*	*60*	*57*	*60*	*62*
Macrolides, lincosamides	**63**	**76**	**81**	**92**	**60**	**53**		**52**	**42**	**37**	**37**	**37**	**40**
Macrolides						*15*		*13*	*13*	*11*	*12*	*12*	*15*
Lincosamides						*38*		*40*	*30*	*27*	*24*	*26*	*26*
Aminoglycosides	**0**	**11**	**12**	**10**	**12**	**18**		**19**	**18**	**20**	**12**	**15**	**13**
Quinolones						**81**		**78**	**85**	**84**	**83**	**90**	**72**
Fluoroquinolones	*70*	*77*	*67*	*74*	*75*	*81*		*78*	*85*	*84*	*83*	*90*	*72*
Other Quinolones (Oxolinic acid)						*0*		*0*	*0*	*0*	*0*	*0*	*0*
Others	**1**	**0**	**0**	**0**	**0**	**0**		**0**	**0**	**0**	**0**	**0**	**0**
Total	**6 986**	**7 771**	**7 815**	**8 714**	**8 970**	**8 960**		**6 472**	**6 230**	**6 036**	**5 990**	**5 737**	**5 672**

ESVAC harmonised sales since 2010

[1]Before 2006 sales of cephalosporins was included in "Others"

1.2.3 Orally administered antimicrobial products

Sales of oral products decreased by 7% during the reporting period (Table 3, Figure 2), but the trends for different antimicrobial classes varied.

Sales of trimethoprim and sulphonamide combination show a strong decreasing trend (-26 % from 2012 to 2015) but still they continued to be the most sold oral antimicrobials (33% of the oral products in 2015) followed by tetracyclines (25%) and aminopenicillins (16%). Major changes were seen for tetracyclines: first increase by 63 % (790 kg) from 2012 to 2014 but thereafter a decrease by 20% (410 kg). These changes are assumed to be mainly due to changes in the treatment of fur animals.

An apparent decrease for sales of 1st generation cephalosporins that are solely used for companion animals was noted (-33%, 280 kg). Sales of aminopenicillins increased (+14%, 124 kg). If 2013 was used as the reference year, an increasing trend is observed also for sales of penicillins and macrolides however it is known that relatively big yearly fluctuations for these classes are possible.

Table 3. Sales of veterinary antimicrobials for oral administration in Finland 2001, 2005–2015, kg active ingredient

Orally administered	2001	2005	2006	2007	2008	2009		2010	2011	2012	2013	2014	2015
Tetracyclines, doxycyclin	**1 672**	**1 135**	**928**	**1 188**	**2 565**	**1 815**		**1 202**	**1 323**	**1 237**	**1 830**	**2 024**	**1 610**
Amphenicols	**4**	**0**	**0**	**0**	**66**	**59**		**59**	**112**	**48**	**95**	**67**	**74**
Betalactams (penicillins)						**811**		**856**	**876**	**1 002**	**970**	**1 069**	**1 164**
Penicillin G						*0*		*0*	*17*	*110*	*47*	*122*	*147*
Aminopenicillins	*424*	*690*	*650*	*654*	*737*	*811*		*856*	*860*	*893*	*923*	*947*	*1 017*
Cephalosporins						**942**		**872**	**1 025**	**871**	**766**	**730**	**587**
1st gen. cephalosporins	*939*	*915*	*940*	*966*	*976*	*942*		*872*	*1 025*	*871*	*766*	*730*	*587*
3rd gen. cephalosporins						*0*		*0*	*0*	*0*	*0*	*0*	*0*
Sulphonamides and trimetoprim	**1 892**	**1 975**	**2 489**	**2 235**	**2 518**	**2 794**		**2 945**	**2 747**	**2 789**	**2 784**	**2 535**	**2 072**
Sulphonamides						*2 329*		*2 454*	*2 289*	*2 324*	*2 320*	*2 112*	*1 726*
Trimetoprim						*466*		*491*	*458*	*465*	*465*	*423*	*346*
Macrolides, lincosamides	**428**	**316**	**538**	**659**	**786**	**541**		**721**	**653**	**717**	**574**	**673**	**720**
Macrolides						*414*		*559*	*519*	*565*	*444*	*510*	*581*
Lincosamides						*126*		*161*	*134*	*152*	*130*	*164*	*139*
Aminoglycosides	**150**	**111**	**110**	**103**	**95**	**101**		**95**	**79**	**76**	**76**	**70**	**62**
Quinolones						**16**		**19**	**17**	**23**	**22**	**22**	**22**
Fluoroquinolones	*11*	*13*	*14*	*14*	*15*	*16*		*19*	*17*	*23*	*22*	*22*	*22*
Other Quinolones (Oxolinic acid)	*20*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*
Pleuromutilines	**95**	**110**	**68**	**20**	**17**	**80**		**48**	**73**	**66**	**43**	**44**	**30**
Others	**1**	**0**	**0**	**0**	**0**	**0**		**0**	**0**	**0**	**0**	**0**	**0**
Total	**5 636**	**5 264**	**5 735**	**5 838**	**7 774**	**7 158**		**6 816**	**6 906**	**6 829**	**7 160**	**7 236**	**6 342**

ESVAC harmonised sales since 2010

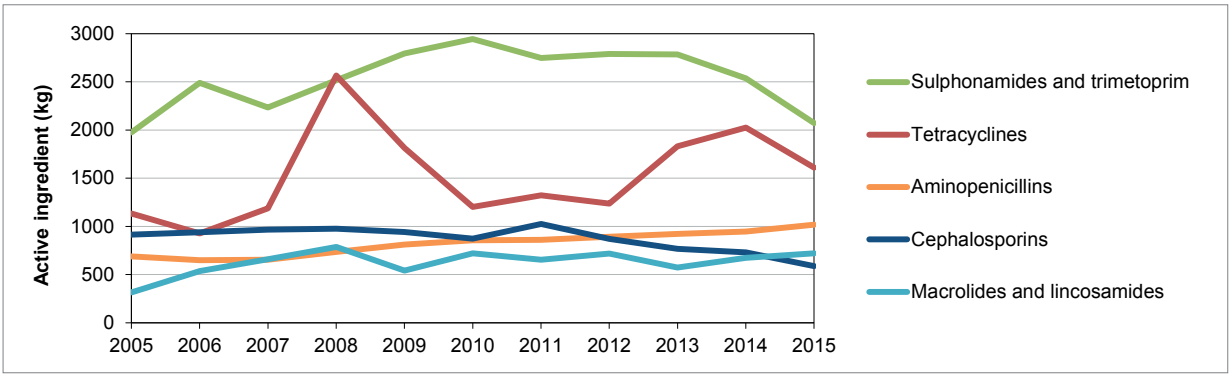


Figure 2. *Sales of products intended for oral administration in Finland, 2005–2015, kg active ingredient*

1.2.3.1 For group treatment

Sales of products suitable (Figure 3) for group treatment increased by 1 000 kg (+31 %) from 2012 to 2014 and remained at the same level (4 200 kg) in 2015. Notable changes were observed especially for tetracyclines and combinations of trimethoprim and sulphonamides. As the statistics is based on the number of packages sold and species specific data is not available, the reasons behind the changes can only be speculated (see section 1.2.3).

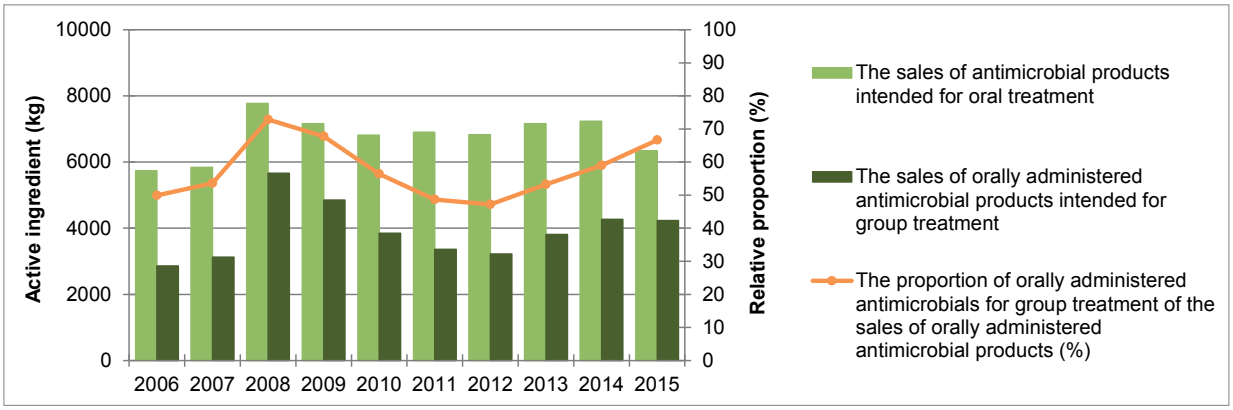


Figure 3. *Total sales and sales of products intended for group treatment 2006–2015*

1.2.4 Intramammary products

The sales of intramammary products used during lactation continued to decrease (-11%) compared to 2012 (Table 4). Penicillin G, cloxacillin and cephalexin were the most used antimicrobial classes for lactating cows and penicillin G and cloxacillin for dry cows.

A downward trend in the number of intramammary tubes for lactation period sold per cow continued from 2012 to 2015. For intramammaries used for dry cow therapy the sales have been stable throughout the years (Figure 4).

Table 4. Sales of intramammary products for use during lactation and for dry cow therapy in Finland 2001, 2005–2015, kg active ingredient

Intramammary tubes, lactation phase	2001	2005	2006	2007	2008	2009	ESVAC harmonised sales since 2010	2010	2011	2012	2013	2014	2015
Penicillin	**225**	**167**	**132**	**143**	**149**	**157**		**104**	**107**	**94**	**154**	**100**	**94**
Other beta lactams	**270**	**162**	**123**	**123**	**106**	**124**		**103**	**101**	**89**	**74**	**70**	**56**
Amino penicillins	*25*	*26*	*19*	*31*	*26*	*23*		*15*	*14*	*11*	*8*	*8*	*7*
Cephalexin	*169*	*68*	*52*	*51*	*40*	*34*		*29*	*30*	*31*	*27*	*22*	*18*
Cloxacillin	*76*	*67*	*52*	*41*	*40*	*67*		*60*	*56*	*47*	*39*	*41*	*31*
Aminoglycosides	**414**	**81**	**72**	**51**	**40**	**34**		**29**	**12**	**1**	**0**	**0**	**0**
Macrolides	**0**	**1**	**1**	**1**	**1**	**1**		**1**	**1**	**0**	**0**	**0**	**0**
Total	**909**	**411**	**329**	**318**	**296**	**316**		**237**	**220**	**185**	**168**	**170**	**150**

Intramammary tubes, dry cow	2001	2005	2006	2007	2008	2009	ESVAC harmonised sales since 2010	2010	2011	2012	2013	2014	2015
Penicillin	**29**	**40**	**33**	**30**	**38**	**44**		**35**	**38**	**28**	**48**	**37**	**44**
Other beta lactams	**125**	**89**	**76**	**79**	**70**	**62**		**67**	**62**	**54**	**47**	**54**	**36**
Amino penicillins	*7*	*7*	*7*	*14*	*6*	*9*		*6*	*6*	*5*	*4*	*3*	*2*
Cephalexin	*45*	*16*	*12*	*10*	*7*	*7*		*6*	*1*	*0*	*0*	*0*	*0*
Cloxacillin	*73*	*65*	*58*	*55*	*57*	*46*		*55*	*55*	*49*	*43*	*50*	*35*
Aminoglycosides	**67**	**34**	**29**	**27**	**22**	**25**		**24**	**20**	**12**	**16**	**15**	**18**
Others	**3**	**0**	**0**	**0**	**0**	**0**		**0**	**0**	**0**	**0**	**0**	**0**
Total	**224**	**163**	**138**	**135**	**130**	**132**		**126**	**120**	**94**	**101**	**106**	**98**

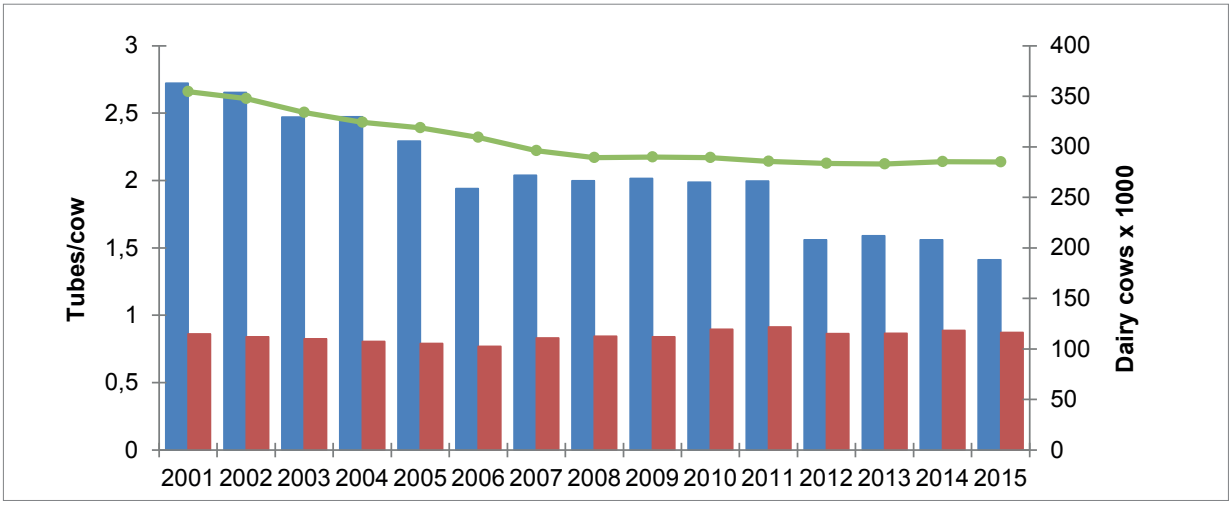


Figure 4. *Antimicrobials for intramammary use during lactation period (blue column) and for dry cow period (red column) and the number of dairy cows (green curve)*

1.2.5 Highest priority critically important antimicrobials, HCIA

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 proportion of HCIAs in 2013–2015 of the overall sales was low: 0.06% for 3rd generation cephalosporins, 3-5% for macrolides and 0.8–0.9% for fluoroquinolones. The sales of 3rd generation cephalosporins and fluoroquinolones decreased during the observation period but the sales of macrolides increased (Tables 1, 2 and 3).

Third generation cephalosporins are only available as injectable products. Due to control measures a significant decrease in the sales of 3rd generation cephalosporins followed already from 2012 to 2013(-43%). The mild decreasing trend has continued in the following years.

The sales of fluoroquinolones peaked in 2014 but thereafter have decreased by 16% (Table 1). Especially, the sales of injectable fluoroquinolones have decreased. In the end of 2014, the legislation was strengthened and critically important antimicrobials are allowed to be used in animals only if according to susceptibility testing or if on epidemiological or veterinary medicinal grounds there is no other efficacious treatment available. Oral fluoroquinolones are only available as tablets/products for small animals. Their sales were stable during the reporting period (Table 3).

Total sales of macrolides have increased by 4% from 2012 to 2015. Majority of the macrolides are sold as oral products (97%) and a relatively big variation in yearly sales is typical. Proportion of macrolides administered by injection is small but distinct increase in their sales was noticed since 2012 (+37%). The change is anticipated to be due to increased respiratory infections observed in young cattle intended for beef production.

1.3 Antimicrobial feed additives

Evira monitors the annual consumption of feed additives by collecting data from feed manufacturers. The Finnish industry producing feed for food-producing animals terminated the use of antimicrobial growth promoters by their own initiative during the 1990s. The use of virginiamycin was stopped already in 1990, the use of bacitracin in 1992, and the use of flavomycin and avoparcin in 1996. No growth promoters are used at present in Finland. The European Union banned the use of avoparcin in 1997 and the use of bacitracin, spiramycin, tylosin and virginiamycin for growth promotion in 1999.

Table 5 presents the total sales of feed additives in Finland in 2005–2015. The coccidiostats monensin and narasin are used as prophylactic anti-parasitic agents mainly in broiler and turkey production. The use of monensin natrium increased significantly in 2013–2015 and in 2015 its use was higher than ever before. The total use of narasin has varied during the last eleven years being at its highest level in 2013–2014 but decreasing again in 2015. Salinomycin has not been used since 2012.

Table 5. The use of antimicrobial feed additives and coccidiostats in Finland in 2005–2015 (kg active substance/year).

Substance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Amprolium (and ethopabate)	0	0	0	0	0	0	0	0	0	0	0
Avoparcin	0	0	0	0	0	0	0	0	0	0	0
Dimetridazole	0	0	0	0	0	0	0	0	0	0	0
Flavomycin	0	0	0	0	0	0	0	0	0	0	0
Lasalocid sodium	0	0	0	0	0	1.4	0	0	0	0	0
Carbadox	0	0	0	0	0	0	0	0	0	0	0
Olaquindox	0	0	0	0	0	0	0	0	0	0	0
Madmuramycin ammonium	1,5	0	0	5	0	0	0	0	0	0	0
Monensin natrium	[1] 8 669	[3] 9 788	[6] 5 560	5 380	5 546	6 801	5 837	7 300	4 614	6 677	12 640
Narasin	3 204	[4] 2 481	[7] 8 007	[9] 7 236	6 056	5 859	7 658	6 567	9 626	9 022	5 478
Salinomycin	[2] 374	[5] 1 328	[8] 35	[10] 108	[11] 1 713	[12] 1 170	[13] 495	0	0	0	0
Nifursol	0	0	0	0	0	0	0	0	0	0	0
Robenidine hydrochloride	0	0	0	0	0	0	0	0	0	0	0
Sum	12 249	13 597	13 601	12 729	13 315	13 832	13 991	13 867	14 240	15 699	18 117

[1] 13.2 kg, [2] 190 kg, [3] 42.6 kg, [4] 1.7 kg, [5] 317 kg, [6] 5 kg, [7] 22 kg, [8] all, [9] 7 kg, [10] 107 kg, [11] 117 kg, [12] 121 kg and [13] 58 kg used in exported feed mixtures

2 Antimicrobial resistance in zoonootic 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.

The susceptibility testing panel for gram-negative bacteria (e.g. antimicrobials included in the testing) was changed in 2014 to be compatible with the European Union harmonized resistance monitoring (2013/652/EU). Details of the sampling and isolation procedures as well as 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.

2.1.1 Antimicrobial resistance in *Salmonella* in 2013–2015

A total of 23, 18 and 27 *Salmonella* isolates were detected among domestic food-producing animals in 2013, 2014 and 2015, respectively. The different serovars encountered from each food-producing animal species are shown in Appendix 4. Like in previous years, *Salmonella* species was mostly encountered in cattle. Among all animal species, *S.* Typhimurium was the most common finding comprising of 19, 11 and 20 isolates in total in 2013, 2014 and 2015, respectively. *S.* Enteritidis was found in six incidences.

The majority of the isolates were susceptible to every tested antimicrobial (Tables 6 and 7). In 2014 and 2015, resistance was found in five isolates from cattle, one isolate from pigs and one isolate from laying hens. All resistant *S.* Typhimurium isolates from cattle had a multiresistant phenotype (resistance to at least ampicillin, chloramphenicol, sulfamethoxazole and tetracycline). Three *S.* Enteritidis isolates (two from cattle and one from a laying hen) were resistant to ciprofloxacin and nalidixic acid, and the poultry isolate also to ampicillin. In addition, one porcine *S.* Typhimurium isolate was resistant to sulfamethoxazole and trimethoprim.

Three *S.* Enteritidis isolates and one *S.* Eastbourne had an elevated MIC for colistin but none of them harboured *mcr-1*. Some serovars have been shown to naturally have higher MIC values suggesting intrinsic resistance but the exact mechanism is not known (Agersø et al., 2012). No resistance against 3rd generation cephalosporins was found.

Between 2013 and 2015, only one strain from domestic food was obtained. This was of serotype *S.* Typhimurium and it was susceptible to all antimicrobials tested.

Table 6. Distribution of MICs for *Salmonella enterica* in production animals in 2013 (n=23).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})																	
				≤0.008	0.016	0.03	0.06	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	2013	0.0	0.0-17.8								87.0	13.0										
Cefotaxime	2013	0.0	0.0-17.8				43.5	39.1	17.4													
Chloramphenicol	2013	0.0	0.0-17.8									39.1	52.2	8.7								
Ciprofloxacin	2013	0.0	0.0-17.8		8.7		91.3															
Florfenicol	2013	0.0	0.0-17.8										95.7	4.3								
Gentamicin	2013	0.0	0.0-17.8							47.8	52.2											
Nalidixic acid	2013	0.0	0.0-17.8									4.3	95.7									
Streptomycin	2013	8.7	1.5-29.5										8.7		82.6	8.7						
Sulfamethoxazole	2013	0.0	0.0-17.8											17.4	78.3	4.3						
Tetracycline	2013	0.0	0.0-17.8								78.3	21.7										
Trimethoprim	2013	0.0	0.0-17.8						47.8	52.2												

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

Table 7. Distribution of MICs for *Salmonella enterica* in production animals in 2014 (n=18) and in 2015 (n=27).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})																	
				≤0.016	0.03	0.06	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	2014	11.1	1.9-36.1							72.2	16.7						11.1				
	2015	7.4	1.3-25.7							59.3	33.3						7.4				
Azithromycin	2014										11.1	55.6	27.8	5.6							
	2015										11.1	66.7	22.2								
Cefotaxime	2014	0.0	0.0-21.9					100.0													
	2015	0.0	0.0-15.5					100.0													
Ceftazidime	2014	0.0	0.0-21.9						100.0												
	2015	0.0	0.0-15.5						100.0												
Chloramphenicol	2014	11.1	1.9-36.1										88.9					11.1			
	2015	3.7	0.2-20.9										96.3					3.7			
Ciprofloxacin	2014	11.1	1.9-36.1	61.1	22.2	5.6		11.1													
	2015	3.7	0.2-20.9	59.3	29.6	7.4		3.7													
Colistin	2014	16.7	4.4-42.3							50.0	33.3	16.7									
	2015	3.7	0.2-20.9							63.0	33.3	3.7									
Gentamicin	2014	5.6	0.3-29.4						55.6	38.9					5.6						
	2015	3.7	0.2-20.9						74.1	22.2					3.7						
Meropenem	2014	0.0	0.0-21.9		100.0																
	2015	0.0	0.0-15.5		81.5	18.5															
Nalidixic acid	2014	11.1	1.9-36.1									83.3	5.6					11.1			
	2015	3.7	0.2-20.9									96.3						3.7			
Sulfamethoxazole	2014	11.1	1.9-36.1										50.0	5.6	27.8		5.6				11.1
	2015	7.4	1.3-25.7											40.7	33.3	18.5					7.4
Tetracycline	2014	11.1	1.9-36.1								88.9						11.1				
	2015	3.7	0.2-20.9								96.3						3.7				
Tigecycline	2014							77.8	22.2												
	2015							22.2	59.3	18.5											
Trimethoprim	2014	0.0	0.0-21.9					66.7	33.3												
	2015	3.7	0.2-20.9					81.5	14.8							3.7					

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.

In addition to a very low prevalence of *Salmonella* in domestic food-producing animals throughout the years 2002–2015, antimicrobial resistance among these isolates is not common. Furthermore, resistance have been mainly detected in *S.* Typhimurium isolates from cattle and also multiresistance occurs. These findings are thought to at least partly be explained by clonal spreading of resistant isolates among Finnish cattle.

2.2 *Campylobacter* spp. in pigs, broilers and cattle

The *Campylobacter jejuni* isolates from broilers in 2013–2015 were obtained through the Finnish campylobacter control programme. The samples were collected at slaughter with the caeca from 10 birds per slaughter batch pooled for examination. One *C. jejuni* isolate/slaughter batch (when found) were tested for antimicrobial susceptibility. The numbers of isolates tested were 76, 88 and 61 in 2013, 2014 and 2015, respectively.

In 2013, *Campylobacter coli* were isolated from pigs in connection with the FINRES-Vet programme. Isolates were obtained from porcine faecal samples (n=326) collected at slaughter. Thermophilic campylobacters (*C. coli* and *C. lari*) were isolated from 66% of the samples, and 63% (n=137) of these were *C. coli* of which 131 were tested for antimicrobial susceptibility.

2.2.1 Developments in the situation in 2013–2015

Broilers (2013–2015)

In 2010–2012, antimicrobial resistance to quinolones, tetracycline, erythromycin and gentamicin ranged from 0% to 2.5% among poultry *C. jejuni* isolates (FINRES-Vet 2010–2012). In 2013–2015, isolates resistant to gentamicin or erythromycin were not detected. However, resistance to quinolones and tetracycline ranged between 0 – 25% and 0 – 17%, respectively, with the highest numbers of resistant isolates found in 2014 (table 8). In 2015, the studied isolates were susceptible to all the tested antimicrobials except for one isolate being resistant to nalidixic acid.

Antimicrobial resistance in campylobacter isolates from broilers has been monitored systematically since 2003 from the isolates gathered annually from the national Campylobacter control programme. Among *C. jejuni* from broilers, resistance levels have been quite stable (Figure 5). Resistance against the tested antimicrobials have varied from rare to low, except in years 2004 and 2014 when tetracycline resistance exceeded 10%. In addition, in 2014, 25% of *C. jejuni* from broilers were quinolone resistant. 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 increase in quinolone resistance is not known.

Table 8. Distribution of MICs for *Campylobacter jejuni* from broilers in 2013 (n=76), 2014 (n=88) and 2015 (n=61).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})												
				≤0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Ciprofloxacin	2013	0.0	0.0-6.0	1.3	60.5	26.3	11.8									
	2014	25.0	16.6-35.6		65.9	8.0	1.1			2.3	3.4	4.5	14.8			
	2015	0.0	0.0-7.4		88.5	9.8	1.6									
Erythromycin	2013	0.0	0.0-6.0				94.7	5.3								
	2014	0.0	0.0-5.2					100.0								
	2015	0.0	0.0-7.4					100.0								
Gentamicin	2013	0.0	0.0-6.0			10.5	64.5	25								
	2014	0.0	0.0-5.2		8.0	52.3	37.5	2.3								
	2015	0.0	0.0-7.4			42.6	57.4									
Nalidixic acid	2013	9.2	2.5-15.4						1.3	52.6	30.3	6.6		9.2		
	2014	25.0	16.6-35.6						14.8	50	10.2		1.1		23.9	
	2015	1.6	0.1-9.9						4.9	65.6	27.9			1.6		
Tetracycline	2013	0.0	0.0-6.0		59.2	39.5	1.3									
	2014	17.0	10.1-26.8				82.9							3.4	13.6	
	2015	0.0	0.0-7.4				100.0									

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.

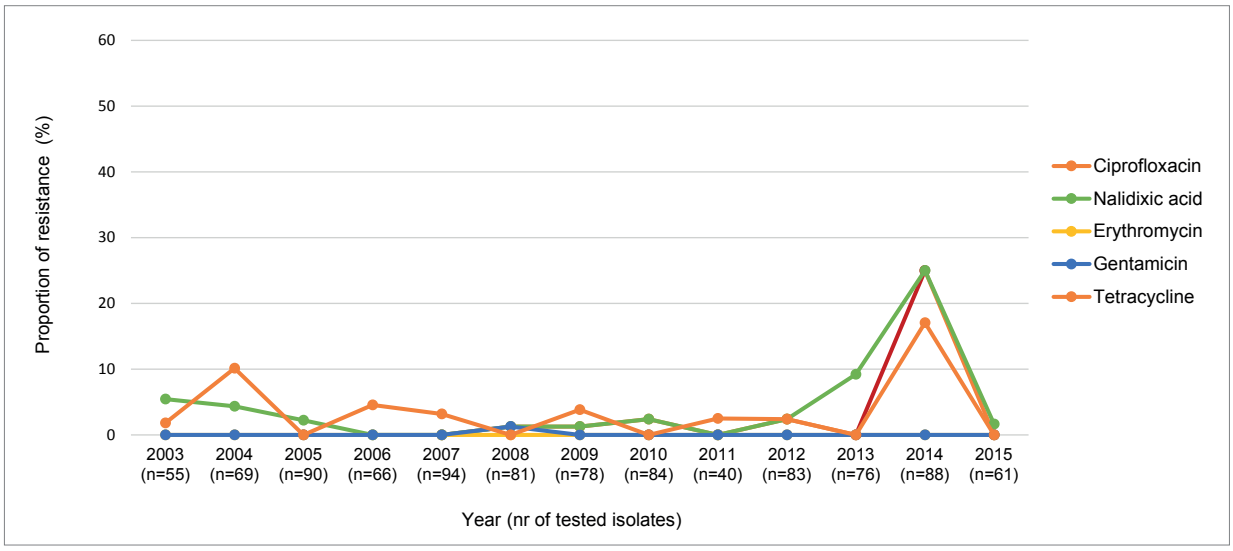


Figure 5. *Resistance in Campylobacter jejuni isolated from broilers at slaughter in Finland in 2003–2015.*

Pigs (2013)

Antimicrobial resistance against quinolones changed from low to high between 2007 and 2010 (FINRES-Vet 2007–2009 and 2010–2012). While 8% of the isolates were quinolone resistant in 2007, in 2010, the next sampling year, quinolone-resistance was 26%. In 2013, the slight decrease was observed as 18% of the isolates were resistant to ciprofloxacin and 19% to nalidixic acid (table 9). In 2007 and 2010, isolates resistant to erythromycin or tetracycline were not detected and situation remained similar in 2013 when only 2% were resistant to erythromycin and no resistance to tetracycline was detected.

Table 9. Distribution of MICs for *Campylobacter coli* from pigs in 2013 (n=131).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})											
			≤0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Ciprofloxacin	18.3	12.3-26.2	3.8	37.4	34.4	6.1				12.2	6.1			
Erythromycin	2.3	0.0-3.6				40.5	26.7	22.9	7.6					2.3
Gentamicin	0.0	0.0-3.6				13.0	80.9	6.1						
Nalidixic acid	19.1	13.0-27.1							13.7	54.2	13.0		2.3	16.8
Tetracycline	0.0	0.0-3.6		19.8	35.9	43.5		0.8						

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.

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

ESBL-, AmpC- and carbapenemase-producing *E. coli* have been screened from the faecal or caecal samples taken at the slaughterhouses in concordance with the FINRES-Vet monitoring programme. From 2015, screening was harmonized in all EU member states and included also fresh meat samples taken at retail (Comission Decision 2013/652/EU). Between 2013 and 2015, ESBL-, AmpC- and carbapenemase-producing *E. coli* were screened from faecal samples from pigs in 2013, caecal samples from broilers in 2014 and caecal samples from pigs in 2015. However, each year the method used was different so the results are not comparable. Details of the isolation procedure and confirmatory tests are described in Appendix 3.

The occurrence of methicillin-resistant *Staphylococcus aureus* (MRSA) was monitored from fresh pork in 2015 from the same samples as in the ESBL/AmpC screening. Details of the isolation procedure and confirmatory tests are described in Appendix 3.

3.1 ESBL/AmpC- and carbapenemase-producing *E. coli* in pigs and broilers in 2013–2015

From pigs, ESBL- or AmpC-producing *E. coli* was isolated from 4.7% (15/320) of the faecal samples in 2013. Of these, one isolate was phenotypically an ESBL-producer and 14 isolates (4.4%) presumptive AmpC-producers. In 2015, presumptive AmpC *E. coli* was isolated from 2.6% (8/306) of the caecal samples, and an ESBL-producing *E. coli* from one sample (table 10).

From broilers (2014), 4% of the 356 samples were positive for ESBL and 3% for AmpC-producing *E. coli* (table 10). No carbapenemase-producing *E. coli* from food-producing animals was found.

3.2 ESBL/AmpC- and carbapenemase-producing *E. coli* in pork and beef in 2015

In 2015, the monitoring included 300 beef and 303 pork samples that represented different production batches. ESBL/AmpC- or carbapenemase-producing *E. coli* was not detected in beef samples. Of all the pork samples analysed, only one (<1%) presumptive AmpC *E. coli* was found (table 10). The number of products of foreign origin was 14 for beef and 11 for pork samples.

Table 10. Results of the specific screening of ESBL-, AmpC- and carbapenemase-producing *E. coli* in animals and meat in 2013–2015.

Year	Source	Sampling stage	Nr of samples	Nr of ESBL[1]	Nr of AmpC[1]	Nr of CPE	% ESBL/ AmpC
2013	Pigs	at slaughter	320	1 (0.3%)	14 (4.4%)	0	4.7%
2014	Broilers	at slaughter	356	14 (3.9%)	11 (3.1%)	0	7.0%
2015	Pigs	at slaughter	306	1 (0.3%)	8 (2.6%)	0	2.9%
2015	Pork, fresh[2]	at retail	303	0	1 (0.3%)	0	0.3%
2015	Beef, fresh[3]	at retail	300	0	0	0	0%

[1]based on phenotypic characterisation

[2]11 pork samples were of foreign origin

[3]14 beef samples were of foreign origin

3.3 MRSA in pork in 2015

Of the 303 fresh pork samples analysed, MRSA was found in 9 (3%) samples. Seven of these were of domestic origin. Of all the samples tested, 294 samples were of domestic origin. Two different *spa* types were detected, t034 (n=6) and t2741 (n=3) which both belong to clonal complex (CC) 398.

4 Antimicrobial resistance in animal pathogens from food-producing animalss

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* spp. from pigs. Details of the sampling, isolation procedures and susceptibility testing are described in Appendix 3.

4.1 Resistance of *Escherichia coli* strains from pig enteritis

Escherichia coli isolates from pig enteritis cases were obtained from clinical or post-mortem samples submitted to Evira. Only one isolate per herd was included. Altogether, 31, 26 and 19 *E. coli* isolates were included from the years 2013, 2014 and 2015, 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 11.

Table 11. Distribution of MICs for *Escherichia coli* from porcine enteritis in 2013 (n=31), 2014 (n=26) and 2015 (n=19).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})																		
				≤0.008	0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	2013	25.8	12.5-44.9								32.3	32.3	6.5	3.2		3.2			22.6			
	2014	26.9	12.4-48.1								42.3	23.1	3.8	3.8	3.8	7.7			15.4			
	2015	42.1	23.2-63.7								47.4	5.3		5.3	5.3	10.5	5.3	5.3	15.8			
Cefotaxime	2013	3.2	0.2-18.5				61.3	32.3	3.2	3.2												
	2014	11.5	3.0-31.3				84.6	3.8		7.7	3.8											
	2015	21.1	8.5-43.3				52.6	15.8	5.3	15.8	5.3											
Chloramphenicol	2013	6.5	1.1-22.8									29	61.3		3.2	6.5						
	2014	11.5	3.0-31.3									30.8	50.0	3.8	3.8	7.7	3.8					
	2015	0.0	0.0-20.9									26.3	52.6	5.3	15.8							
Ciprofloxacin	2013	19.4	8.1-38.1			41.9	38.7	3.2	6.5		3.2	6.5										
	2014	26.9	12.4-48.1		57.7	7.7	7.7	3.8	15.4	3.8	3.8											
	2015	31.6	15.4-54.0		52.6	10.5	5.3	5.3	15.8	5.3		5.3										
Colistin	2013	0.0	0.0-13.7								93.5	6.5										
	2014	0.0	0.00-16.0							65.4	26.9	7.7										
	2015	0.0	0.0-20.9							73.7	21.1	5.3										
Florfenicol	2013	0.0	0.0-13.7										90.3	6.5	3.2							
	2014	0.0	0.0-16.0										53.8	42.3	3.8							
	2015	0.0	0.0-20.9										47.4	47.4	5.3							
Gentamicin	2013	0.0	0.0-13.7						6.5	51.6	35.5	6.5										
	2014	0.0	0.00-16.0					3.8		80.8	11.5	3.8										
	2015	0.0	0.0-20.9							84.2	15.8											
Kanamycin	2013	9.7	2.5-26.9											90.3	3.2	6.5						
	2014	7.7	1.3-26.6											92.3		7.7						
	2015	0.0	0.0-20.9											100.0								
Nalidixic acid	2013	19.4	8.1-38.1									58.1	19.4	3.2		3.2	6.5	3.2	6.5			
	2014	26.9	12.4-48.1									65.4	7.7			3.8		19.2	3.8			
	2015	36.8	19.2-59.0									57.9	5.3			5.3	5.3	15.8	10.5			
Streptomycin	2013	32.3	17.3-51.5									3.2	29	25.8	9.7	3.2	3.2	3.2	9.7	12.9		
	2014	52.0	31.8-71.7									4.0	24.0	8.0	12.0		8.0	4.0	24.0	16.0		
	2015	57.9	36.3-76.9									5.3	26.3	5.3	5.3	10.5	5.3	21.1	10.5	10.5		
Sulfamethoxazole	2013	22.6	10.3-41.5											61.3	9.7	6.5		3.2			3.2	16.1
	2014	50.0	30.4-69.6											38.5	11.5							50
	2015	57.9	36.3-76.9											31.6	10.5						5.3	52.6
Trimethoprim/ sulfamethoxazole[1]	2013	15.4	5.0-35.7							80.8	3.8			15.4								
	2014	30.8	15.1-51.9							61.5	7.7			30.8								
	2015	42.1	23.2-63.7							57.9			5.3	36.8								
Tetracycline	2013	29.0	14.8-48.2								58.1	12.9				9.7	9.7	9.7				
	2014	38.5	20.9-59.3								53.8	3.8		3.8	3.8	7.7	7.7	15.4	3.8			
	2015	68.4	46.0-84.6								21.1	10.5				10.5	10.5	31.6	15.8			
Trimethoprim	2013	19.4	8.1-38.1					32.3	35.5	6.5	3.2	3.2				19.4						
	2014	30.8	15.1-51.9					26.9	23.1	15.4		3.8				30.8						
	2015	42.1	23.2-63.7					21.1	31.6	5.3					5.3	36.8						

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.

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

As in previous years, multiresistance (resistance to ≥3 antimicrobial classes) was commonly detected with 29%, 42% and 68% multiresistant isolates found in 2013, 2014 and 2015, respectively. These isolates were found to be resistant against representatives from up to 6 antimicrobial classes.

Similarly as before, resistance was commonly detected against ciprofloxacin (19%, 27% and 32%) tetracycline (29%, 39% and 68%), streptomycin (32%, 52% and 58%), sulfamethoxazole (23%, 50%, and 58%), and trimethoprim (19%, 31% and 42%), all percentages respective to 2013, 2014 and 2015.

However, unlike in previous years, resistance against 3rd generation cephalosporins was detected in all of the study years with one, three and four isolates. Seven of these were phenotypically AmpC-producers.

Colistin was included in the resistance monitoring of *E. coli* already in 2010 but it is now reported in the FINRES-Vet for the first time due to the finding of new horizontally spreading resistance mechanisms detected both in Europe and Asia (Liu et al. 2015, Xavier et al. 2016). However, no colistin-resistant isolates were found among pathogenic *E. coli*. Also, no resistance was detected against gentamicin or florfenicol in any of the years and resistance to kanamycin was at low level (<10%).

4.2 *Actinobacillus pleuropneumoniae* from respiratory diseases of pigs

A. pleuropneumoniae is the most import respiratory pathogen in growing pigs in Finland. Since the beginning of 2015, commercial Sensititre™ BOPO panel has been used to assess the MIC distribution in *A. pleuropneumoniae* isolates from clinical submissions. Results from year 2015 only using CLSI clinical breakpoints are presented here. No resistance towards the tested antimicrobial was seen. However, 67% of the isolates were classified as intermediate against oxytetracycline.

Table 12. Distribution of MICs for *Actinobacillus pleuropneumoniae* from pigs in 2015 (n=15).

Substance	%I+R	95% C.I.	Distribution (%) of MICs (mg l^{-1})										
			≤0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin	0.0	0.0-25.4		86.7	13.3								
Florfenicol	0.0	0.0-25.4		100.0									
Ceftiofur	0.0	0.0-25.4		100.0									
Penicillin[1]			6.7	6.7	73.3	13.3							
Oxytetracycline	66.7	41.7-84.8			33.3	66.7							
Tulathromycin	0.0	0.0-25.4								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 hyodysenteriae* from pigs

Sikava is a health classification register for pig farms in Finland. Farms belonging to Sikava has to be free of swine dysenteria and thus *B. hyodysenteriae* is seldom detected in Finland. However, in 2013 *B. hyodysenteriae* caused two separate dysenteria outbreaks altogether in 15 farms and in 2014 in 5 farms (one outbreak). No cases were detected in 2015. There are no standardised breakpoints established for *Brachyspira hyodysenteriae* from swine. When epidemiological cut-off values established in Sweden (Pringle et al. 2012) were applied to MIC distributions of *B. hyodysenteriae*, decreased susceptibility was seen in 6% of the isolates to tiamulin and lincomycin, 6.7% to doxycycline, 11.8% to tylosin and valnemulin, and 13.4% to tylvalosin (table 13).

Table 13. Distribution of MICs for *Brachyspira hyodysenteriae* from pigs in 2013–2014 (n=17).

Substance	Distribution (%) of MICs (mg l^{-1})													
	≤0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline[1]			40.0	33.3	20.0			6.7						
Lincomycin					82.4	11.8		5.9						
Tiamulin		82.4	5.9	5.9	5.9									
Tylosin							41.2	17.6	23.5			11.8		5.9
Tylvalosin[1]				33.3	20.0	33.3	6.7					6.7		
Valnemulin	76.5	11.8			11.8									

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.

[1]n=15

4.4 *Brachyspira pilosicoli* from pigs

There are no standardised breakpoints established for *Brachyspira pilosicoli* from swine. As guide for the choice of antimicrobial for treatment of spirochaetal diarrhoea, a clinical breakpoint for tiamulin of >2 mg/L and for tylosin of >16 mg/L are used in Sweden. With these breakpoints, 25 - 32% of *B. pilosicoli* isolates were resistant to tylosin yearly. No resistance against tiamulin was detected.

Table 14. Distribution of MICs for *Brachyspira pilosicoli* from pigs in 2013 (n=19), 2014 (n=28) and 2015 (n=31).

Substance	Year	Distribution (%) of MICs (mg l^{-1})													
		≤0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	2013			10.5	57.9	15.8	10.5	5.3							
	2014[1]			29.2	41.7	8.3	16.7	4.2							
	2015			51.6	19.4	3.2	16.1	6.5	3.2						
Lincomycin	2013					57.9	5.3		5.3	15.8	10.5	5.3			
	2014					50.0	10.7		3.6	7.1	21.4	7.1			
	2015					51.6	6.5	6.5	9.7	3.2	9.7	9.7	3.2		
Tiamulin	2013		68.4	21.1	5.3	5.3									
	2014		60.7	14.3	3.6	17.9		3.6							
	2015		77.4	9.7	9.7	3.2									
Tylosin	2013							31.6	42.1					15.8	10.5
	2014							35.7	14.3	17.9				14.3	17.9
	2015							64.5	3.2		3.2				29.0
Tylvalosin	2013				21.1	36.8	15.8	10.5	5.3	5.3	5.3				
	2014[1]				25.0	29.2	16.7	8.3		12.5	8.3				
	2015				58.1	12.9	6.5	3.2	3.2	9.7	6.5				
Valnemulin	2013	63.2	21.1	10.5		5.3									
	2014	60.7	14.3		17.9	7.1									
	2015	74.2	9.7	6.5	6.5	3.2									

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.

[1]n=24

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

Since the beginning of 2015, MICs for bovine respiratory pathogens *Pasteurella multocida*, *Mannheimia haemolytica* and *Histophilus somni* have all been analysed

using commercial Sensititre™ BOPO panel instead of previously used disk diffusion test or VetMIC™. Therefore only results from 2015 are presented here. Isolates were approximately from 105 farms. One isolate from each bacterial species from one farm was included in testing.

No resistance against the tested antimicrobials was seen in *H. somni* isolates. Resistance or decreased susceptibility against at least one of the tested antimicrobials was more common in *M. haemolytica* than *P. multocida* – 25.7% vs. 9.6%, respectively. Resistance to oxytetracycline and penicillin was most common. Oxytetracycline resistance was 4.4% and 8.6%, and penicillin resistance 1.5% and 5.7% among *P. multocida* and *M. haemolytica*, respectively. Resistance was mostly seen in isolates from specialized calf rearing units and was rare in samples from dairy farms. On one farm, one *P. multocida* strain was resistant against both penicillin and oxytetracycline, and another strain was resistant to fluoroquinolones and showed decreased susceptibility against florfenicol. Otherwise, among P. *multocida* and *M. haemolytica* isolates, resistance was only seen against single antimicrobial. In VetPath study in Europe in 2009–2012, resistance or decreased susceptibility to tetracycline was 11.9% in *P. multocida* and 12.1% in *M. haemolytica* (El Garch et al. 2016). Penicillin was not included in the VetPath study.

Table 15. Distribution of MICs for *Histophilus somni* from bovine respiratory disease in 2015 (n=28).

Substance	%I+R	95% C.I.	Distribution (%) of MICs (mg l^{-1})										
			≤0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin[1]				100.0									
Ceftiofur	0.0	0.0-15.0		100.0									
Danofloxacin[1]			100.0										
Enrofloxacin	0.0	0.0-15.0	100.0										
Florfenicol	0.0	0.0-15.0		92.9	7.1								
Oxytetracycline[1]					89.3	7.1	3.6						
Penicillin	0.0	0.0-15.0	100.0										
Tulathromycin	0.0	0.0-15.0				3.6	28.6	57.1	10.7				

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.

[1]clinical brakpoints or EUCAST ECOFFs not available

Table 16. Distribution of MICs for *Mannheimia haemolytica* from bovine respiratory disease in 2015 (n=35).

Substance	%I+R	95% C.I.	Distribution (%) of MICs (mg l^{-1})										
			≤0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin[1]	0.0	0.0-12.3		91.4	8.6								
Ceftiofur	0.0	0.0-12.3		97.1	2.9								
Danofloxacin	0.0	0.0-12.3	100.0										
Enrofloxacin	0.0	0.0-12.3	100.0										
Florfenicol	0.0	0.0-12.3		60.0	40.0								
Oxytetracycline	8.6	2.2-24.2			51.4	40.0			8.6				
Penicillin	17.1	8.1-32.7	48.6	34.3	11.4	5.7							
Tulathromycin	0.0	0.0-12.3					80.0	20.0					

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

[1]clinical breakpoints not avalaible for bovines, EUCAST ECOFF for *P. multocida* used

Table 17. Distribution of MICs for *Pasteurella multocida* from bovine respiratory disease in 2015 (n=135).

Substance	%I+R	95% C.I.	Distribution (%) of MICs (mg l^{-1})										
			≤0.125	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin[1]	1.5	0.3-5.8		98.5				0.7		0.7			
Ceftiofur	0.0	0.0-3.5		98.5			1.5						
Danofloxacin	0.7	0.04-4.7	98.5	0.7		0.7							
Enrofloxacin	0.7	0.04-4.7	99.3			0.7							
Florfenicol	0.7	0.04-4.7		68.9	28.1	2.2		0.7					
Oxytetracycline	4.4	1.8-9.8			68.1	11.9	13.3	2.2	4.4				
Penicillin	1.5	0.3-5.8	97.0	1.5						1.5			
Tulathromycin	0.7	0.04-4.7				47.4	38.5	8.9	3.0	1.5	0.7		

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

[1]clinical breakpoints not avalaible for bovines, EUCAST ECOFF for *P. multocida* used

4.6 *E. coli* from colibacillosis and other *E. coli* infections in broilers

Escherichia coli serotype O18 caused quite severe colibacillosis outbreaks in broiler farms in 2014. Serotype O78 was the main serotype seen in 2015 causing severe colibacillosis in all Nordic countries. Because of these outbreaks, the number of tested *E. coli* isolates in 2014 and 2015 is exceptionally high. The isolates originate from almost 200 broiler farms. Colibacillosis was treated with antimicrobials occasionally only in parent flocks. No antimicrobials have been used in production flocks. Based on EUCAST ECOFFs, resistance against tetracycline was most common (7.6-17.4%). However, a decreasing trend from 2013 to 2015 was seen. Fluoroquinolone resistance appeared in 2014 (8%) and increased further the year after (16.7%). This peak might have been caused by a new line of parent birds imported to Finland. It is a well-known fact that *E. coli* clones are transmitted from parents to the next generation in broilers. A peak in resistance against 3rd generation cephalosporins was seen in 2014. Multiresistance (resistance to ≥3 antimicrobial classes) was uncommon.

Table 18. Distribution of MICs for *Escherichia coli* from broiler colibacillosis in 2013 (n=23), 2014 (n=137) and 2015 (n=132).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})																	
				≤0.008	0.016	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	2013	0.0	0.0-17.8								13.0	82.6	4.3									
	2014	13.9	8.8-21.1								29.9	54.7	0.7	0.7		2.2		2.9	8.8			
	2015	6.1	2.9-12.0								68.2	24.2	0.8	0.8		0.8			5.3			
Cefotaxime	2013	0.0	0.0-17.8			4.3	73.9	17.4	4.3													
	2014	4.4	1.8-9.7			6.6	82.5	5.8	0.7	1.5		2.9										
	2015	0.0	0.0-3.5			0.8	87.9	10.6	0.8													
Ceftazidime	2013	4.3	0.02-24.0						87.0	8.7	4.3											
	2014	5.8	2.7-11.6						92.7	1.5	1.5	0.7	1.5	2.2								
	2015	0.8	0.04-4.8						89.4	9.8		0.8										
Ciprofloxacin	2014	7.7	2.5-19.4	1.9	57.7	13.5	19.2	1.9		3.8	1.9											
	2015[1]	16.7	9.0-28.3	12.1	56.1	15.2			12.1	4.5												
Enrofloxacin	2013	0.0	0.0-17.8					100.0														
	2014	8.0	4.3-14.3					92.0		3.6	2.9	0.7		0.7								
	2015[2]	16.7	9.7-26.7					83.3	1.2	14.3	1.2											
Tetracycline	2013	17.4	5.7-39.6								73.9	8.7					17.4					
	2014	13.1	8.2-20.2								83.2	3.6				8.8	4.4					
	2015	7.6	3.9-13.9								86.4	6.1				4.5	1.5	1.5				
Trimethoprim	2013	0.0	0.0-17.8							95.7	4.3											
	2014	6.6	3.2-12.5							93.4			5.1	1.5								
	2015[1]	1.5	0.08-9.3					12.1	45.5	24.2	16.7					1.5						
Sulfamethoxazole	2015[1]	4.5	1.2-13.6											48.5	40.9	6.1				3.0		1.5

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

[1]n=66

[2]n=84

4.7 *S. 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 from the study period.

In 2013, 20 isolates originating from nine farms were studied, whereas 29 isolates from 11 farms and 36 isolates from 19 farms were studied in 2014 and 2015, respectively. During the monitoring period, a vast majority of the isolates were susceptible to all the tested antimicrobials (table 16). Altogether, four isolates were found to produce β-lactamase, all isolated in 2014 and originating from different farms. No MRSA isolates were found. One isolate was resistant to sulfamethoxazole-trimethoprim in 2013 and three isolates from years 2013 and 2015 were found to have MIC-values above ECOFF for tetracycline.

Table 19. Distribution of MICs for *Staphylococcus aureus* from tenosynovitis in broilers in 2013 (n=20), 2014 (n=29) and 2015 (n=36).

Substance	Year	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})								
				≤0.125	0.25	0.5	1	2	4	8	16	>16
Cefoxitin	2013[1]	0.0	0.0-21.9					11,1	88.9			
	2014	0.0	0.0-14.6						100.0			
	2015	0.0	0.0-12.0					2.8	97.2			
Oxacillin	2013	0.0	0.0-20.1		40.0	35.0	25.0					
	2014	0.0	0.0-14.6		3.4	55.2	37.9	3.4				
	2015	0.0	0.0-12.0			30.6	50.0	19.4				
Oxytetracycline[2]	2013	5.0	0.3-26.9				95.0		5.0			
	2014	0.0	0.0-14.6				100.0					
	2015	5.6	1.0-20.0				94.4				5.6	
Penicillin[3]	2013	0.0	0.0-20.1	95.0	5.0							
	2014	13.8	5.5-30.6	93.1				6.9				
	2015	0.0	0.0-12.0	100.0								
Trimethoprim/ sulfamethoxazole[4]	2013	5.0	0.3-26.9			95.0		5.0				
	2014	0.0	0.0-14.6			100.0						
	2015	0.0	0.0-12.0			100.0						

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.

[1]n=18

[2]EUCAST ECOFF of tetracycline used

[3]resistance procentages based on beta-lactamase production

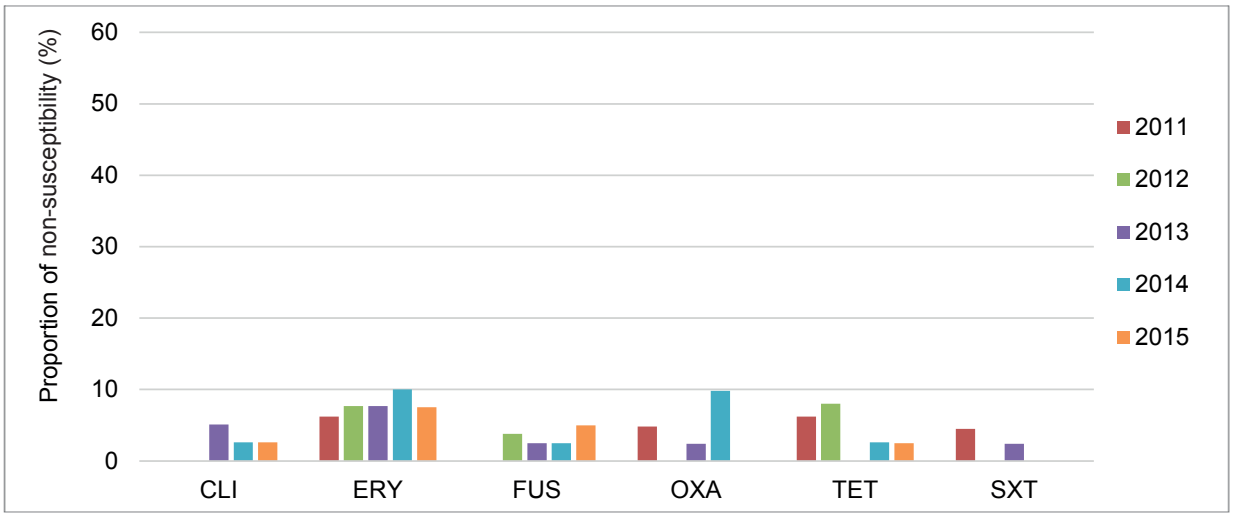
[4]concentration of trimethoprim given, tested with sulfamethoxazole in concentration ratio of 1:20

5 Antimicrobial resistance in animal pathogens from companion animals

Antimicrobial resistance figures from companion animal pathogens were collected from the Clinical Microbiology Laboratory of the Faculty of Veterinary Medicine, University of Helsinki. A reporting period covers June 2011 – December 2015. Approximately 64% of specimens were from the Veterinary Teaching Hospital of the University of Helsinki and 36% from private clinics. All data concern bacterial isolates derived from clinical infections. Details of the susceptibility testing are described in Appendix 3.

5.1 *Staphylococcus aureus* from companion animals and horses

The material included 170 *S. aureus* isolates (21 – 41 isolates per year) from companion animals and horses. Antimicrobial resistance was very low to low (figure 6), except for penicillin. Oxacillin resistance ranged from 0 – 9.8%, being highest in 2014. Of oxacillin resistant isolates (6/170), two were BORSA (borderline oxacillin resistant *S. aureus*) and the rest were *mec*A-gene positive MRSA. Beta-lactamase results were available from 127 isolates, of which 65% were positive. Beta-lactamase production was more common in canine and feline *S. aureus* isolates (80%, 67/84) than in equine isolates (35%, 15/43), ($p<0.0001$, *Chi*-square test).

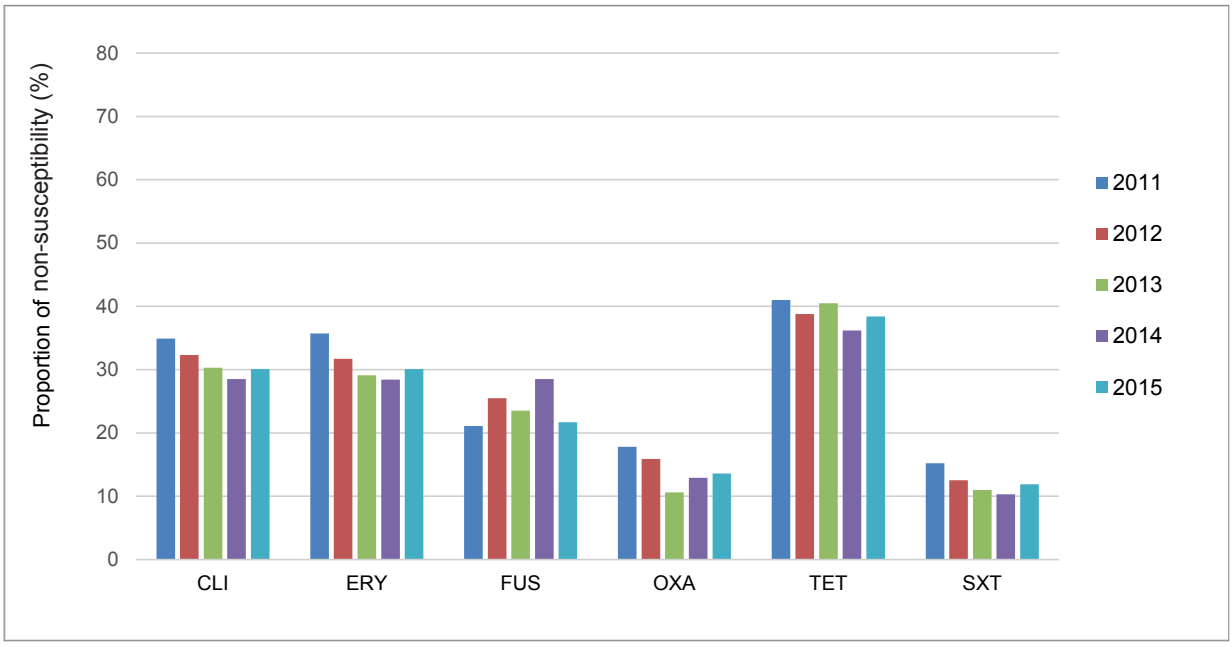


CLI, clindamycin; ERY, erythromycin; FUS, fusidic acid; OXA, oxacillin; TET, tetracycline; SXT, trimethoprim-sulfamethoxazole

Figure 6. *Antimicrobial non-susceptibility (%) in Staphylococcus aureus from horses, cats and dogs in Finland in 2011–2015. The number of tested isolates per year: 21 (2011), 26 (2012), 41 (2013, 2014, and 2015).*

5.2 *Staphylococcus pseudintermedius* from dogs and cats

Antimicrobial resistance among *Staphylococcus pseudintermedius* isolates was moderate to high and remained rather stable over the years (figure 7). Total number of tested isolates was 1952 (210-500 isolates per year), of which 98.8% were from dogs. The highest resistance figures were found to tetracycline (36 – 41%), erythromycin (28 – 36%), and clindamycin (29 – 35%). The proportion of oxacillin non-susceptibility ranged from 18% (2011) to 11% (2013). In 2015, 14% of isolates were non-susceptible to oxacillin and harboured the *mec*A gene. Sulphonamide-trimethoprim resistance ranged from 10 to 15%, being 12% in 2015. Regarding enrofloxacin, chloramphenicol, gentamicin and amikacin, consistent data were available only for 2015: 7.3% were non-susceptible to enrofloxacin, 18.4% to chloramphenicol, and 6.6% to gentamicin. Amikacin resistance was not observed.

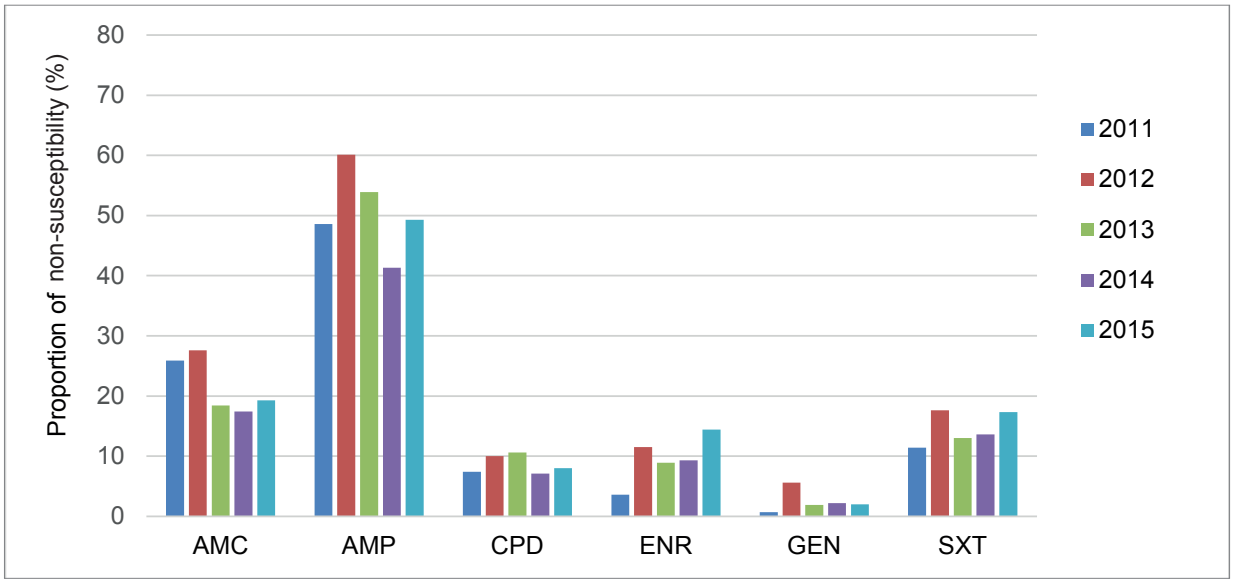


CLI, clindamycin; ERY, erythromycin; FUS, fusidic acid; OXA, oxacillin; TET, tetracycline; SXT, trimethoprim-sulfamethoxazole

Figure 7. *Antimicrobial rnon-susceptibility (%) in Staphylococcus pseudintermedius isolates in Finland in 2011–2015. Number of tested isolates per year were as follows: 210 (2011), 441 (2012), 500 (2013), 405 (2014), 396 (2015). For each antimicrobial there can be small variations from these numbers.*

5.3 *Escherichia coli* from dogs and cats

There were 1 628 canine and feline *E. coli* isolates (139 - 440 per year), of which almost 88% were from dogs. More than 40% of isolates were non-susceptible to ampicillin in each year, reaching 49% in 2015 (figure 8). Nearly 20% of the isolates were non-susceptible to amoxicillin-clavulanic acid. Sulphonamide-trimethoprim non-susceptibility ranged from 11% (2011) to 17% (2015). Enrofloxacin non-susceptibility percentages were increasing and reached 14% in 2015. The proportion of cefpodoxime non-susceptibility, indicating a reduced susceptibility to 3rd generation cephalosporins, as well as proportion ESBL and AmpC isolates are shown in table 20.



AMC, amoxicillin; AMP, ampicillin; CPD, cefpodoxime; ENR, onrofloxacin; GEN, gentamicin; SXT, trimethoprim-sulfamethoxazole

Figure 8. *Antimicrobial non-susceptibility (%) in canine and feline E. coli in Finland in 2011–2015. Number of tested isolates: 139 (2011), 321 (2012), 360 (2013), 368 (2014) and 440 (2015).*

Table 20. Proportion of *E. coli* with reduced susceptibility to cefpodoxime (CDP), and proportion of ESBL and AmpC positive isolates in canine and feline *E. coli* in Finland in 2011–2015.

Year	*E.coli* (n)	CPD (%)	ESBL (%)	AmpC (%)
2011	136	7	2	ND[1]
2012	320	10	4	ND
2013	359	11	3	ND
2014	367	7	2	5
2015	440	8	2.5[2]	5

[1]ND, Proportion of AmpC were not determined

[2]Includes two isolates with an NDM-profile

5.4 *Escherichia coli* from horses

There were 118 clinical *E. coli* isolates from horses during 2011–2015. Due to small number, the antimicrobial resistance figures are calculated from the total number of tested isolates. Resistance was at a high level for ampicillin (68%), sulfamethoxazole-trimethoprim (56%), and gentamicin (29%). Fluoroquinolone (enrofloxacin) resistance was present in 15% of the isolates. Also 15% of the isolates showed reduced susceptibility to 3rd generation cephalosporins. The proportion of ESBL isolates was 6.9% for the whole period. During the last two years (2014–2015) the respective proportion was 12%.

5.5 Other pathogens from horses

During the period of 2011-2015, 170 *Streptococcus equi* ssp. *zooepidemicus* isolates were investigated. All were susceptible to penicillin and only one (0.6%) was resistant to sulfamethoxazole-trimethoprim. Of other Lancefield group streptococci (n=52), none was resistant to these agents. Of *Actinobacillus* spp. isolates (mainly *A. equuli* ssp. *haemolyticus* and *equuli*), 9/60 had high MIC to penicillin (15%, MIC > 2 mg/L) and 4/57 (7%) had MIC ≥ 32 mg/L to sulfamethoxazole-trimethoprim. Thirty-five percent of equine staphylococci (n=43) produced beta-lactamase.

Of isolates belonging to the KESC-group (*Klebsiella-Enterobacter-Serratia-Citrobacter*) (n=115), 61% were resistant to enrofloxacin, 78% to gentamicin, and 79% to sulfamethoxazole-trimethoprim. ESBL production was detected in 35% of the KESC isolates.

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-producing animals (MARAN, 2008).

In this report, the results of indicator *E. coli* from slaughtered pigs in 2013 and 2015, and from slaughtered broilers in 2014 are presented. Each isolate represents a different pig herd or a broiler production batch. Details of the sampling, isolation procedures and susceptibility testing are described in Appendix 3.

Escherichia coli in pigs and broilers harmonized monitoring of antimicrobial resistance in bacteria isolated from food-producing animals and food thereof started in 2014 in the whole European Union (Comission Decision 2013/652/EU). Therefore, the susceptibility testing panel for gram-negative bacteria (e.g. antimicrobials included in the testing) was changed in 2014.

6.1 *Escherichia coli* in pigs and broilers

The number of *E. coli* isolates from pigs were 315 in 2013 and 217 in 2015, and from broilers 175 (in 2014).

Pigs

Resistance among *E. coli* varied from low to rare against many of the antimicrobials (tables 21 and 22). However, moderate to high resistance levels were found against five antimicrobials: tetracycline (21 - 24%), streptomycin (18%), sulfamethoxazole (14 - 17%), trimethoprim (12 - 15%) and ampicillin (10 - 14%). Trimethoprim and sulfamethoxazole resistance percentages were somewhat higher in 2015 than in 2013 but tetracycline had decreased from 24% to 21%. Streptomycin was only tested in 2013. Tetracycline resistance was the most common observed resistance trait in *E. coli* – so the situation was the same as observed in the previous report. This can still be largely explained by the common use of tetracycline in pig production. Furthermore, the combination of sulphonamides and trimethoprim is used widely which can explain the moderate resistance to those antimicrobials. Also, ampicillin resistance has increased from 2013 to 2015.

Overall, resistance to these antimicrobials has increased during the last decade (figure 9). However, resistance to fluoroquinolones and 3rd generation cephalosporins is still rare among commensal *E. coli* from pigs.

Resistance to two antimicrobials was found in 5% of the *E. coli* isolates in 2013 and 6% in 2015. Multiresistance was also observed: the amount of isolates resistant to three, four or more than four antimicrobials was 4%, 7% and 4% in 2013 (n=315), and 8%, 6% and 5% in 2015 (n=217), respectively. In 2013, two of the 315 isolates were resistant to 3rd generation cephalosporins, both of them phenotypically AmpC-producing *E. coli*. On the contrary, resistance to 3rd generation cephalosporins was not found in 2015.

Table 21. Distribution of MICs for indicator *Escherichia coli* in pigs in 2013 (n=315).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg l-1)																		
			≤0.008	0.015	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	9.5	6.6-13.4								24.4	55.9	9.5	0.6			0.6		8.9			
Cefotaxime	0.6	0.1-2.5			7.3	60.0	31.7	0.3	0.3	0.3											
Chloramphenicol	1.0	0.3-3.1									6.3	65.7	25.7	1.3	0.3	0.6					
Ciprofloxacin	1.9	0.8-4.3		2.2	47.6	48.3	1.0	0.6	0.3												
Colistin	0.0	0.0-1.5							74.6	22.9	2.5										
Florfenicol	0.0	0.0-1.5										55.9	41.6	2.5							
Gentamicin	1.0	0.3-3.1						0.3	25.7	61.6	11.4	0.6	0.3								
Nalidixic acid	1.3	0.4-3.5								1.9	57.1	37.5	2.2		0.3	0.3	0.3	0.3			
Streptomycin	18.4	14.4-23.2									0.6	9.5	57.1	14.3	1.6	3.5	5.4	4.8	3.2		
Sulfamethoxazole	13.7	10.2-18.1											47.0	20.3	15.9	3.2				0.3	13.3
Tetracycline	23.5	19.0-28.7								63.8	12.1	0.6		0.3	7.9	10.2	4.8	0.3			
Trimethoprim	12.4	9.1-16.7					2.5	19.7	48.6	16.5	0.3		0.6		11.7						

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.

Table 22. Distribution of MICs for indicator *Escherichia coli* in pigs in 2015 (n=217).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg l-1)																	
			≤0.015	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	14.3	10.1-19.8							1.4	28.6	50.7	5.1	0.4	0.5	0.5	12.9				
Cefotaxime	0.0	0.0-2.2					100.0													
Ceftazidime	0.0	0.0-2.2						100.0												
Chloramphenicol	0.9	0.2-3.6										91.3	7.8	0.9						
Ciprofloxacin	0.5	0.0-3.0	94.4	4.6	0.5		0.5													
Colistin	0.0	0.0-2.2							86.2	13.8										
Gentamicin	0.9	0.2-3.6						35	59	5.1	0.4		0.5							
Meropenem	0.0	0.0-2.2		98.1	1.4	0.5														
Nalidixic acid	0.5	0.0-3.0									99.0	0.5				0.5				
Sulfamethoxazole	17.1	12.5-22.9										79.7	3.2							17.1
Tetracycline	21.2	16.1-27.4								71.4	7.4				6.0	15.2				
Tigecycline	0.0	0.0-2.2					77.0	23.0												
Trimethoprim	15.2	10.8-20.8					34.1	43.8	6.9		0.5				14.7					

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.

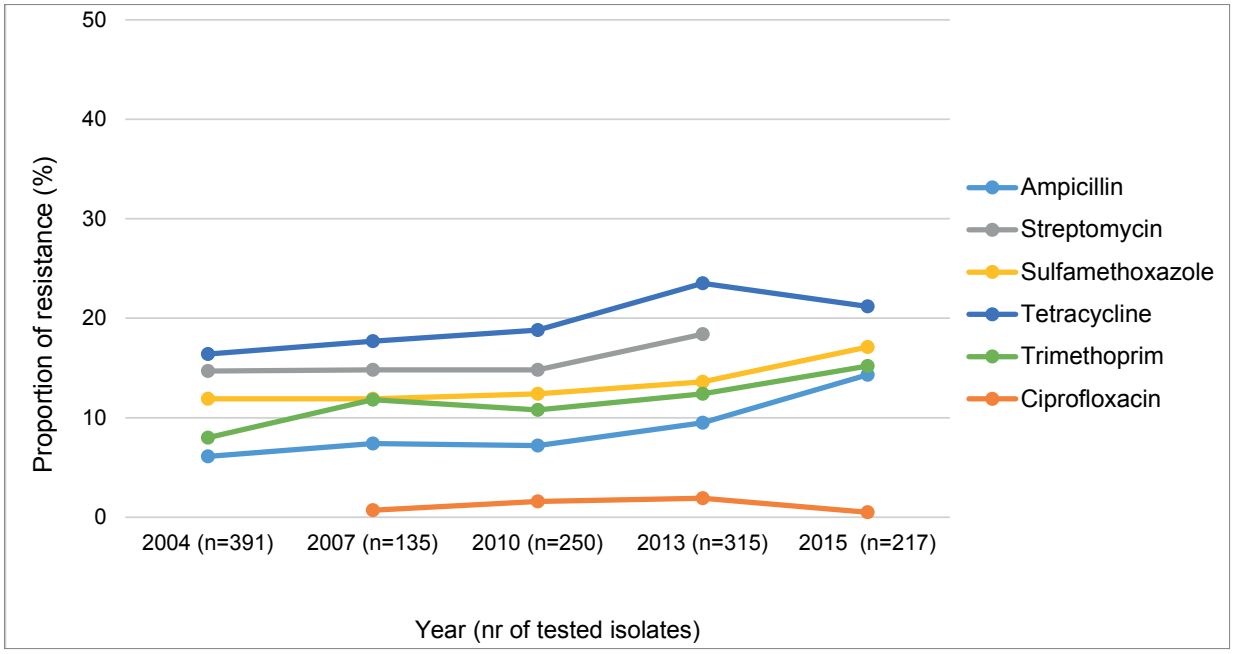


Figure 9. *Resistance in indicator E. coli from pigs to selected antimicrobials in 2004–2015.*

Broilers

In broilers, resistance among *E. coli* was low or rare against most of the examined antimicrobials (table 23). The resistance was moderate only against tetracycline. Ten percent of the *E. coli* isolates were resistant to two antimicrobials. Resistance to three antimicrobials was found in 5% of the isolates and none of the isolates was resistant to four or more antimicrobials. Resistance to 3rd generation cephalosporins was not found among indicator *E. coli* from broilers when isolates were selected randomly from plates without selection.

In Finland, no antimicrobials to treat bacterial infections are used in broiler production flocks. Also, resistance levels have only slightly varied in 2002–2014 and the overall situation is still very favourable in commensal *E. coli* from broilers (figure 10).

Table 23. Distribution of MICs for indicator Escherichia coli in broilers in 2014 (n=175).

Substance	%R	95% C.I.	Distribution (%) of MICs (mg l^{-1})																	
			≤0.015	0.032	0.064	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	>1024
Ampicillin	4.6	2.2-9.2							2.3	48	42.3	2.9				4.6				
Cefotaxime	0.0	0.0-2.7					100.0													
Ceftazidime	0.0	0.0-2.7						100.0												
Chloramphenicol	0.0	0.0-2.7										98.3	1.7							
Ciprofloxacin	4.6	2.2-9.2	89.7	5.7			4.6													
Colistin	0.0	0.0-2.7							92.0	8.0										
Gentamicin	0.6	0.0-3.6						50.3	45.1	4.0	0.6									
Meropenem	0.0	0.0-2.7		98.3	1.7															
Nalidixic acid	4.6	2.2-9.2									94.9	0.6			1.1	1.1	2.3			
Sulfamethoxazole	6.9	3.8-12.0										92.0	1.1							6.9
Tetracycline	10.9	6.9-16.7								85.7	3.4				1.7	9.1				
Tigecycline[1]	0.0	0.0-2.7					80.6	19.4												
Trimethoprim	5.1	2.5-9.8					45.1	40.0	9.7		0.6				4.6					

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.

[1]seven isolates with MIC value 1 retested; MIC value was re-defined as ≤0.25 or 0.5

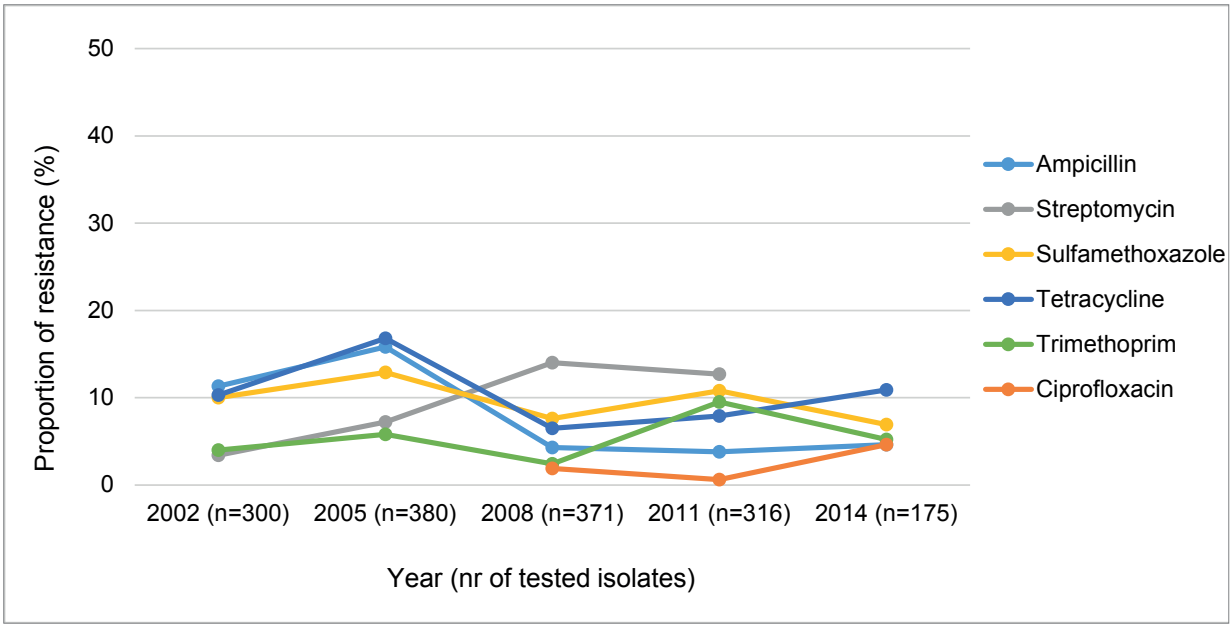


Figure 10. *Resistance in indicator E. coli from broilers to selected antimicrobials in 2002–2014.*

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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 (formerly the statistics of Tike, the Information Centre of the Ministry of Scriculture and Forestry, Finland).

Table 24. Number of livestock (1000) in Finland in 1995, 2000, 2005 and 2010–2015.

	1995	2000	2005	2010	2011	2012	2013	2014	2015
Dairy cows	399	364	319	289	286	284	283	285	285
Suckling cows	29	28	35	55	57	58	57	58	59
Cattle > 1 year	298	300	277	278	273	268	271	268	264
Calves < 1 year	422	365	329	303	299	303	300	303	307
TOTAL, Cattle	1 148	1 057	959	926	914	913	912	914	915
Boars and sows	168	190	181	154	146	136	128	123	NA[2]
Pigs > 20 kg	757	694	769	804	797	779	815	760	NA
Piglets < 20 kg	476	412	451	409	392	375	365	362	NA
TOTAL, pigs	1 400	1 296	1 401	1 367	1 335	1 290	1 308	1 245	1 235
Laying hens	4 179	3 110	3 128	3 394	3 304	3 173	3 432	3 645	3 521
Chicks	1 482	914	954	838	745	743	858	714	662
Broilers	4 276	7 918	5 472	4 616	5 421	6 038	6 861	7 341	6 993
Turkeys	80	215	495	280	308	295	274	292	248
Other poultry[1]	315	395	477	459	457	512	555	584	597
TOTAL, poultry	10 358	12 570	10 538	9 587	10 236	10 761	11 981	12 577	12 021

[1]Includes e.g. broilerhens, ducks, geese, ostrich, farmed mallards and pheasants.

[2]NA, not available

Table 25. Number of farms in Finland in 1995, 2000, 2005, 2010 and 2013–2015.

	1995	2000	2005	2010	2013	2014	2015
Cattle farms total	43 095	30 087	21 493	15 641	13 416	12 885	12 389
Pig farms total	7 304	4 382	3 086	2 078	1 637	1 486	1 323
Poultry farms total	7 650	2 636	1 925	1 304	1 207	1 299	1 301

Table 26. The production of meat and fish (million kg) in Finland in 1995, 2000, 2005, 2010 and 2013–2015.

	1995	2000	2005	2010	2013	2014	2015
Beef[1]	96	90	85	82	80	82	86
Pork[1]	166	172	203	203	194	186	192
Poultry[1]	42	64	87	96	111	113	117
Total	306	328	376	383	387	383	397
Fish[2]	17	15	14	12	14	13	15

[1] In slaughterhouses; [2] for human consumption, ungutted

Table 27. The production of milk in Finland in 1995, 2000, 2005, 2010 and 2013–2015.

	1995	2000	2005	2010	2013	2014	2015
Milk production; per animal (litres)	5 982	6 786	7 505	7 896	7 977	8 201	8 323
Total milk production (million litres)	2 396	2 450	2 362	2 268	2 260	2 330	2 365

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).

Harmonized EU surveillance

Veterinary antimicrobial agents included in the data

The collection of sales data has been harmonized 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. Sales of local products is 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	QG51AA; QG51AC; QG51AE; QG51AX; QG51BA; QG51BC; QG51BE
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. *C. coli* from pigs were isolated from the same samples as indictor bacteria in the FINRES-Vet programme.

Indicator bacteria

Indicator *E. coli* was collected from broiler caeca (in 2014) and pig faeces (in 2013) or caeca (in 2015). The samples originated from healthy animals at slaughter between January or February and December. The number of randomly taken samples from each slaughterhouse was proportional to the annual slaughter volume. Each isolate represented one flock or herd. The broiler slaughterhouses accounted approximately for 98% (in 2014), and the pig slaughterhouses for 93 % (in 2013) and 95 % (in 2015) of the total number of slaughtered animals in Finland.

Animal pathogens

Clinical isolates originated from diagnostic submissions or postmortem examinations done in Evira laboratories. *Escherichia coli* was isolated from pigs with enteritis, the samples were taken from the contents of the gastrointestinal tract. *Staphylococcus aureus* from broiler tenosynovitis cases were isolated from clinical and 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 liver, heart or bone marrow. *Brachyspira hyodysenteriae* and *B. 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 since June 2011; a reporting period thus covers June 2011 – December 2015.

Isolation and identification of bacteria

Zoonotic bacteria

Salmonella 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.

Indicator *E. coli*

Intestinal content was directly spread on Brilliance™ *E. coli*/coliform Selective Agar (Oxoid) and incubated overnight at 37°C. Purple colonies were selected for susceptibility testing.

Animal pathogens from food-producing animals

Isolation and identification of pathogens was performed by conventional culture and biochemical/MALDI-TOF methods in Evira in Veterinary Bacteriology Unit or Production Animal and Wildlife Health Unit laboratories. Pathogens were from various types of clinical specimens like faeces, deep nasopharyngeal swabs or organ/faecal samples from post mortem examinations.

Animal pathogens from companion animals

Identification of pathogens was performed by conventional biochemical methods 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-producing *E. coli* from broilers and pigs was made from the same samples as indicator bacteria. Broilers were screened in 2014 (n=356) and pigs in 2013 (n=320) and 2015 (n=306). Also, meat from pigs and bovines were included in 2015 as part of the EU-wide monitoring based on Comission Decision 2013/652/EU. From the faecal or caecal samples, one gram of intestinal content was suspended in 10 ml of buffered peptone water (BPW) (Merck, Germany) containing 1 mg/l cefotaxime (Sigma-Aldrich, Germany) and incubated overnight at 37°C (except in 2015 when BPW without cefotaxime was used). From the meat samples, 25 grams of meat was suspended in 225 ml of BPW and incubated overnight at 37°C. Ten microliters of the overnight suspension was spread on MacConkey agar (Becton, Dickinson & Company, France) plates containing 1 mg/l cefotaxime and incubated overnight at 37°C (in 2013–2014) or 44°C (in 2015). Typical lactose fermenting pink colonies were further spread on the same plates and incubated overnight at 37°C. Typical colonies were picked and the species confirmation was done with API 20E test (BioMérieux® SA, France) or Maldi Biotyper® (Bruker Daltonics, Germany). The screening of carbapenemase producing *E. coli* was done in parallel with the ESBL/

AmpC screening using CHROMagar™ KPC (CHROMagar™ Orientation + KPC Supplement; CHROMagar, France) plates in 2013-2014, or CARBA and OXA-48 plates (bioMerieux, France) in 2015. From the overnight suspension of PBW, 10 µl were spread on selective plates and after incubation (as recommended by the manufacturer), typical colonies were identified with API 20E test or Maldi Biotyper®.

Confirmation of ESBL/AmpC- or carbapenemase-producing *E. coli* and *Salmonella* spp.

All *E. coli* and *Salmonella* spp. that had cefotaxime and/or ceftatzidime MIC above ECOFF and all *E. coli* isolates from the specific ESBL/AmpC screening were phenotypically characterized with AmpC & ESBL ID Set (D68C, Mast Diagnostics, UK) and/or broth microdilution method (see below).

Screening of MRSA in pork

Meat from pigs were screened for methicillin-resistant *Staphylococcus aureus* (MRSA) in 2015. Meat samples were randomly selected from the retail. Twenty-five grams of meat was diluted in 225 ml of Müller-Hinton broth (DifcoTM Müller Hinton Broth, United States) with 6.5% NaCl (Merck, Germany), and incubated overnight at 37°C. From the suspension, 1 ml was diluted in 9 ml of tryptic soy broth (TSB) (BBLTM TSB, United States) which included 3.5 g/l of cefoxitin (Sigma-Aldrich, United States) and 75 g/l of aztreonam (Sigma-Aldrich, United States). After an overnight incubation at 37°C, 10 µl was spread on MRSA Select™ agar plates (BioRad, United States) and incubated at 37°C. Typical colonies were confirmed with a PCR of the *mecA* gene using primers described in Murakami *et al.* (1991). All MRSA isolates were *spa* typed (Shopsin *et al.*, 1999).

Susceptibility testing

In 2013, the susceptibility testing of zoonotic and indicator bacteria as well as animal pathogens isolated from food-producing animals was performed with a broth microdilution method (VetMIC™, Department of Antibiotics, National Veterinary Institute, Uppsala, Sweden). From 2014, the Sensititre™ susceptibility panels (TREK Diagnostic Systems Ltd, United Kingdom) were used for indicator *E. coli*, salmonella and for the confirmation of suspective ESBL/AmpC-producing bacteria, and from 2015, for the respiratory pathogens of pigs and bovines. The testing was performed following the procedures of the available Clinical and Laboratory Standards Institute (CLSI) standard (CLSI VET01-A4). Susceptibility testing was performed at Evira, Food and Feed Microbiology Research Unit and Production Animal and Wildlife Health Unit in Seinäjoki. The current epidemiological cut-off (ECOFF) values are used to separate the wild-type population (referred as susceptible) from the non-wild-type isolates (referred as resistant) (table 29). When available, clinical breakpoints of the current CLSI document (CLSI VET01S-3rd Ed.) were used for the porcine and bovine respiratory pathogens. There are no standardised breakpoints approved for *Brachyspira sp.* from swine. A proposal for epidemiological cut-off values (Pringle at al. 2012) was applied to *B. hyodysenteriae* MICs. Clinical breakpoints of >2 µg/ml for tiamulin and >16 µg/ml for tylosin was applied to *B. pilosicoli*.

Table 29. Epidemiological cut-off values (mg l^{-1}) 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			>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		>8			
Meropenem	>0.125	>0.125			
Nalidixic acid	>16	>16	>16	>16	
Oxacillin					>2
Tetracycline	>8	>8	>1	>2	>1
Tigecycline		>0.5			
Streptomycin	>16	>16			
Sulfamethoxazole	>256 [1]	>64			
Trimethoprim	>2	>2			
Trimethoprim/ sulfamethoxazole[2]		>1			>0.5

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

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 2011-2013 and CLSI VET01-A4 from 2013 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) were used. An exception was the fucidic acid non-susceptibility breakpoint, which was ≤ 23 (FiRe-standard, version 6). Beta-lactamase activity was tested with Cefinase™ disks (Becton Dickinson, NJ, USA). *S. aureus* with oxacillin or cefoxitin MIC values >2 or >4, respectively, were tested for the presence of the *mecA* gene 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 Food and Feed 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.

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™ 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 2013–2015

Table 30. *Salmonella enterica* serovars isolated from the main food-producing animal species in Finland in 2013–2015.

Serotype	Year	N	Cattle	Pigs	Poultry (Gallus gallus)	Turkeys
S. Typhimurium	2013	19	8	4	5	2
	2014	11	10	-	1	-
	2015	20	13	6	1	-
S. Enteritidis	2013	2	2	-	-	-
	2014	2	2	-	-	-
	2015	2	1		1	-
S. Livingstone	2013	1	-	-	1	-
	2014	-	-	-	-	-
	2015	1	-	-	1	-
S. Eastbourne	2013	-	-	-	-	-
	2014	2	2	-	-	-
	2015	-	-	-	-	-
S. Mbandaka	2013	1	-	1	-	-
	2014	-	-	-	-	-
	2015	-	-	-	-	-
S. Infantis	2013	-	-	-	-	-
	2014	1	-	1	-	-
	2015		-	-	-	-
S. Konstanz	2013	-	-	-	-	-
	2014	-	-	-	-	-
	2015	1	1	-	-	-
S. Derby	2013	-	-	-	-	-
	2014	-	-	-	-	-
	2015	1	-	1	-	-
S. Coeln	2013	-	-	-	-	-
	2014	-	-	-	-	-
	2015	1	1	-	-	-
S. Bovismorbificans	2013	-	-	-	-	-
	2014	1	-	1	-	-
	2015	-	-	-	-	-
S. Stockholm	2013	-	-	-	-	-
	2014	1	-	1	-	-
	2015	-	-	-	-	-
S. Cerro	2013	-	-	-	-	-
	2014	-	-	-	-	-
	2015	1	-	-	1	-

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