UK Veterinary Antibiotic Resistance and Sales Surveillance

UK-VARSS 2013

Veterinary Medicines Directorate

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Foreword

This is the second combined antimicrobial resistance and sales report published under the acronym UK-VARSS 2013 by the Veterinary Medicine Directorate (an executive agency of Defra), and covers data from 2009-2013 (sales), and 2011-2013 (resistance). The layout has been revised in order to aid interpretation, data is presented in tabular and graphic form with resistance data divided by animal species as well as bacterial species. Although there are limitations to the data, it is anticipated that veterinarians and farmers will be able to use the report when prescribing antibiotics or developing health plans. The report will also be of relevance to policy writers, academics and members of the public with an interest in veterinary and public health. The VMD is dedicated to improving the surveillance of veterinary antibiotics and resistance and future plans include monitoring of antibiotic consumption, structured surveillance of previously unmonitored pathogens and joint reporting of human and veterinary data.

For both sales and resistance surveillance we have used the Heads of Medicines Agencies definition of antimicrobials and antibiotics[1] which have also been adopted by EPRUMA[2].

For the resistance data, resistance has been defined based on human clinical breakpoints. The intent, in the future, is to move towards agreed animal species clinical breakpoints. However, even for future reports, we will retain human clinical breakpoints for food-borne pathogens due to their relevance for human medicine.

Professor S.P. Borriello

[1] www.hma.eu/fileadmin/dateien/Veterinary_medicines/00-HMA_Vet/02-HMA_Task_Force/03_HMA_vet_TF_AMR/2012_11_HMA_agreed_AB_AM_definitions.pdf

[2] http://www.epruma.eu/component/downloads/downloads/76.html

Executive Summary

Overall the trends observed in 2013 are in keeping with those reported in the 2012. Sales of antibiotics reduced from 60mg/PCU to 56mg/PCU in food producing species, but there has been little variation in sales over a six year period, and the 2013 figure is equal to the average (mean) for the period. Of the antibiotics which are recognised as critically important for human use, a small decrease (120kg) was observed in the volume of sales of 3rd and 4th generation cephalosporins; sales of fluoroquinolones increased by 180kg between 2012 and 2013, and sales of macrolides increased by 2 tonnes over the same period.

When considering resistance, no major changes were detected in the level of resistance in isolates between 2012 and 2013. Of the bacteria that are of interest to human public health, none of the *Salmonella* spp. isolated from cattle, sheep or pigs, were resistant to ciprofloxacin (fluoroquinolone), however 1.4% of *Salmonella* isolates from chickens, and 7% from turkeys, were resistant to ciprofloxacin. Resistance to 3rd and 4th generation cephalosporins was not detected in *Salmonella* spp. isolates from any animal species apart from pigs, in which 0.6% of isolates were resistant.

Of *E. coli* isolates collected by scanning surveillance (obtained from diagnostic submissions and therefore may be pathogenic or commensal strains), greatest resistance to fluoroquinolones was observed in cattle, with 12% of isolates resistant to enrofloxacin. 4% of *E. coli* isolates from sheep were resistant to enrofloxacin, which was an increase from 0.6% in 2012. Resistance to enrofloxacin in isolates from pigs remained stable at 8%, and resistance to enrofloxacin in *E. coli* from poultry was low (2% in chickens, 0% in turkeys). Resistance of *E. coli* to 3rd and 4th generation cephalosporins was greatest in cattle with 13% of isolates resistant to cefotaxime, a decrease from 18% in 2011. Large variation is seen in the levels of resistance in *E. coli* in different age groups of animals, with the level of resistance decreasing after weaning. It should therefore be recognised that the majority of resistant isolates reported via scanning surveillance were obtained from neonatal or pre-weaned animals and resistance is much less frequently observed in isolates from adults.

Also of note was the detection of a Livestock Associated (LA) strain of MRSA in an isolate from a turkey, which is thought to be the first isolate of LA-MRSA in a food producing animal in the UK. These strains are prevalent in other European countries.

The proportion of *Brachyspira hyodysenteriae* isolates, which were resistant to tiamulin increased between 2011 and 2013. This is significant as *B. hyodysenteriae* is a cause of dysentery in pigs and few antibiotics are authorised for treatment of this infection, increasing resistance may therefore result in compromised welfare. Overall the number of isolates reported was low (29 isolates over three years); this remains an area to be closely monitored, but is not of major concern at present.

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Chapter 1 – Introduction

Antimicrobial resistance, in particular antibiotic resistance, is recognised as a significant and growing concern in both the medical and veterinary sector. The scale of the threat posed by antimicrobial resistance, and our approach to minimising the development and transmission of resistance, are outlined in the UK cross government 5 Year Strategy, published in 2013[3].

Consistent, ongoing collation and analysis of surveillance data on the levels of resistance present in bacteria from animals, humans and their environment is essential to underpin our understanding of how resistant bacteria, and resistance genes, move between different bacterial populations.

The focus of this report is on bacteria of veterinary origin. While the main clinical concern in the UK at present is resistance that impacts on our ability to effectively treat human disease, we recognise that to address this issue we need to look at all potential sources of resistance, as well considering the potential implications of resistance for animal welfare.

There are clear links between use of antibiotics in animals and development of resistance in zoonotic bacteria that cause disease in people, such as *Salmonella* spp. and *Campylobacter* spp. Our programme of active surveillance of resistance in these bacterial species has recently expanded and will, in future, permit trend analysis that can be cross-linked to surveillance programmes of the same bacterial species from human clinical cases.

There is also evidence that resistance genes present in commensal bacteria in animals can transfer to human pathogenic bacteria, via consumption of animal products. The significance that this route of transmission plays in the overall resistance picture in human medicine is not yet defined. Surveillance of resistance in commensal bacteria, i.e. commensal *E. coli*, from healthy animals contributes to our understanding of the potential risk this route of transmission may pose.

It is imperative, for the health and welfare of our animal populations, that resistance in veterinary pathogenic bacteria does not develop to a point that limits our ability to treat disease. At present, as far as we are aware, the incidence of disease in animals in the UK that has been effectively untreatable with antimicrobials permitted for use is rare, and limited to a small number of cases of swine dysentery (*Brachyspira hyodysenteriae*). Our programme of surveillance of veterinary pathogenic bacteria acts as an early warning system for new and emerging resistance patterns, but does not currently permit trend analysis of changes in resistance patterns that can be extrapolated with confidence to bacterial populations present in the wider national animal herd. Our aspiration in future is to move towards active surveillance of resistance in key veterinary pathogens, to aid veterinary surgeons in making appropriate, informed, prescribing decisions.

We know that one of the key drivers for development and selection of resistance in bacteria is the use of antibiotics. However, there are other factors, such as biosecurity, that impact on the prevalence of resistance present within different animal populations. Monitoring levels of antibiotic consumption in parallel with surveillance of resistance in bacteria from the same animal populations will increase our understanding of the complex nature of resistance. It will also aid in identifying any sub-optimal use of antibiotics in the veterinary sector, and facilitate veterinary surgeons and animal keepers to adopt practices of responsible use.

[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244058/20130902_UK_5_year_AMR_strategy.pdf

Our plans for development of both our antibiotic consumption and antibiotic resistance surveillance programmes are outlined in more detail on page 19. We do not underestimate the challenge posed in achieving the aspirations we have outlined, but are committed to improving surveillance of veterinary antibiotic resistance.

Summary of findings

The following paragraphs provide a summary of the findings. Data on UK antibiotic sales covers the period 2008 to 2013 and were collected on a UK wide basis. Data for antibiotic resistance covers the period 2011 to 2013. Scanning surveillance activities which contribute to these resistance data were conducted in England and Wales, and structured surveillance activities were conducted on a UK wide basis.

Antibiotic Sales Data

The PCU is the unit of measure used in the EU to compare sales as related to animal populations and demographics. The figure for all antibiotic sales in food producing species was 56 mg/PCU for 2013. This represents a decrease from 60mg/PCU in 2012. Over the six year period, the value ranged from 52-62 mg/PCU and the 2013 figure was equal to the mean average. It is positive that a decline in sales has been observed, however when compared to the reduction that has been achieved over the same time period in some other EU member states the reduction is small.

For the antibiotics which are recognised as critically important for human use, an increase was seen in the sale of macrolides from 6.23 mg/PCU in 2012 to 6.94 mg/PCU in 2013. In terms of volume of antibiotic sales, macrolides increased by two tonnes in 2013; sales of macrolides have been increasing since 2010. A small increase was also observed in the volume of sales of fluoroquinolones between 2012 and 2013, from 2.4 to 2.6 tonnes (0.35 to 0.36 mg/PCU), despite a voluntary ban introduced by the poultry industry. Due to limitations with data collection no explanation can be offered for the sales patterns observed, highlighting the need for more rigorous surveillance of antibiotic consumption. The sales of 3rd and 4th generation cephalosporins decreased in 2013 by 120 kg, translating to a decline from 0.20mg/PCU in 2012 to 0.18mg/PCU in 2013.

Reductions were noted in the sales of intramammary antibiotics, with 1.54g of active ingredient per dairy cow being sold compared to 1.99g per dairy cow in 2012. A decrease was seen in the volume of dry cow therapy sold, from 1.04g per cow in 2012 to 0.89g per cow in 2013. Lactating cow therapy sales also decreased from 0.95g per cow in 2012 to 0.65g per cow in 2013.

Total antibiotic sales decreased in 2013 from 445 tonnes to 420 tonnes, of these sales tetracyclines were the most widely sold class accounting for 44% of all antibiotic sales in 2013, with 184 tonnes sold. Tetracyclines have consistently had the highest sales of the seven antibiotic classes analysed; encouragingly, sales did decrease by six tonnes between 2012 and 2013.

Of particular note is the fact that sales of antibiotics authorised for use in food producing species decreased by 26 tonnes (7%) between 2012 and 2013, from 381 tonnes to 355 tonnes. Sales of products authorised for use in non-food producing animals accounted for 36 tonnes (9%) of the total annual sales, with an increase of one tonne since 2012.

Medicated feed for food-producing animals accounted for 60% of veterinary antibiotic products sold, the majority of which are sold for use in pigs and poultry. Sales of antibiotics as medicated feed decreased by 23 tonnes in 2013 compared to 2012. Changes have been proposed to the EU legislation on medicated feed with the intention of reducing the risk of antibiotic resistance. The proposal includes banning the use of

medicated feed for the prevention of disease.[4] It is anticipated that the new regulation will reduce the use of medicated feeds further.

Antibiotic Resistance Data

Data on antibiotic resistance were collected via two methods of surveillance, scanning surveillance and structured surveillance. It should be remembered that scanning surveillance is a passive form of surveillance, which means the findings may not be representative of the population. Structured surveillance does however provide a representative sample and therefore can be extrapolated to the wider population.

Scanning surveillance

LA- MRSA

Livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA) was detected as an incidental finding in a fattening turkey, from a non-intensive farm, in November 2013. LA-MRSA is prevalent in other European countries but this is believed to be the first case of LA-MRSA in livestock in the UK.

Salmonella

Of the 2886 *Salmonella* spp. isolates tested in 2013, 64.2% were fully susceptible to all antibiotics tested; this was an improvement from 59.7% in 2012 and 59.4% in 2011. Resistance to critically important antibiotics was less than 2% in all animal species apart from turkeys, in which resistance to ciprofloxacin peaked at 7%.

Escherichia coli

Data for isolates of *E. coli* are categorised in to age groups, as the prevalence of resistant isolates in younger animals is known to be greater than adults and can skew the results if all isolates are collated together (Hinton 1989). The majority of isolates were obtained from faeces or intestinal contents and include animal pathogenic as well as commensal strains. In 2013, 81% of isolates from neonatal calves were resistant to ampicillin; this may reflect the use of dry cow intramammary infusions in the dam and transfer of residual antibiotics in colostrum leading to selection pressure. It is possible that selection pressure may have occurred historically and resistant strains have adapted to the neonatal calf, meaning the resistant isolates can exist in the absence of antibiotic treatment. Tetracycline resistance was also common with 78% of the 629 neonatal calf isolates being resistant. When considering the critically important antibiotics, resistance to cefotaxime was observed in 13% of isolates from neonatal calves and 3% of isolates from neonatal lambs, resistance to ceftazidime was lower at 8% in calves and 1% in sheep. In neonatal piglets 4% of isolates were resistant to cefpodoxime. Potentially this is of concern as *E. coli* can colonise and infect humans; however, the relationship of these strains to strains colonising or causing infections in man is, for most isolates, assumed to be distant.

Mastitis pathogens

Streptococcus uberis was the most frequently isolated mastitis pathogen in cattle; resistance to neomycin increased from 54% in 2011 to 70% in 2013, however only one *S. uberis* isolate amongst 705 tested was resistant to penicillin. *Streptococcus agalactiae* from cases of bovine mastitis remained susceptible to penicillins and macrolides, which is an important result with implications for treatment. *Staphylococcus*

[4] For more information on the proposed changes to EU regulation on medicated feed visit http://ec.europa.eu/food/food/animalnutrition/labelling/medicated_feed_en.htm

aureus isolates from bovine mastitis were frequently resistant to ampicillin, though resistance to other antibiotics was less common. Resistance to amoxicillin/clavulanic acid in these isolates has increased from 11% to 25% over the period 2011-2013; no MRSA isolates were detected in cattle.

Respiratory pathogens

Resistance was not detected to enrofloxacin or florfenicol in *Pasteurella multocida, Mannheimia haemolytica, Bibersteinia trehalosi* or *Histophilus somni* in cattle, sheep and pigs. Although isolates generally remain susceptible to many of the older veterinary therapeutic antibiotics, ampicillin resistance was detected in *P. multocida* from cattle in 2013.

Other veterinary pathogens

The proportion of isolates of *Brachyspira hyodysenteriae* resistant to tiamulin increased in 2012-2013 compared to previous years. Although the sample size was small, this is of concern as there are a limited number of authorised antibiotics available for the treatment of swine dysentery. If resistance to these antibiotics occurs the only option for control may be the depopulation of herds. *Streptococcus dysgalactiae isolates* from cattle remain susceptible to ampicillin or penicillin. Tylosin resistance was detected in 45-58% of *Streptococcus suis* isolates, while penicillin resistance was only detected in three of the 180 isolates from pigs over 2011-2013.

Structured surveillance

***Salmonella* spp.**

Of the isolates from broilers, 63% were fully susceptible, 55% were resistant to sulphonamides and trimethoprim, 37% were resistant to tetracycline, 4% were resistant to ciprofloxacin and nalidixic acid, no isolates were resistant to cefotaxime. In laying hens 85% of samples were fully sensitive; none of the isolates from layers were resistant to ciprofloxacin, nalidixic acid or cefotaxime. Of the isolates from pigs 26% were fully susceptible; 21% of isolates were *S*. Typhimurium, of which 10% were fully susceptible. Tetracycline, ampicillin, streptomycin and sulphonamide resistance were common and occurred in 81-87% of isolates. Resistance to fluoroquinolones or 3rd generation cephalosporins was not detected in *S*. Typhimurium isolates.

***Campylobacter* spp.**

Ciprofloxacin and nalidixic acid resistance was demonstrated in 31% of *C. jejuni* isolates from broilers and tetracycline resistance was observed in 48%. Of the *C. coli* isolates from broilers 42% were resistant to ciprofloxacin and nalidixic acid, 55% were resistant to tetracycline. In the isolates of *C. coli* from pigs, 79% were resistant to tetracycline, 67% were resistant to streptomycin, 13% were resistant to nalidixic acid and 2% were resistant to nalidixic acid.

Commensal *E. coli*

Cefotaxime resistance was identified in 0.6% of isolates and ciprofloxacin resistance occurred in 1.3% of isolates obtained from pigs. Greatest resistance observed was to tetracycline (67%) and sulphonamides (52%). Following culture on enriched media the overall prevalence of CTX-M ESBL *E. coli* in the 637 pigs, after accounting for clustering within farms, was 22.0% (95% CI 17.8-26.1).

Looking at the overall picture, it appears that sales and resistance have remained largely the same over the reporting period. In 2013 a reduction was seen in the sales of antibiotics authorised for food producing animals, intramammary preparations and medicated feed. This decrease should be recognised and commended and might represent the beginning of a further downward trend. There are also some promising results from the resistance data. Resistance to the critically important antibiotics was on the whole low, with the exception of macrolide resistance in certain porcine isolates and 3rd and 4th generation cephalosporin resistance in *E. coli* in calves and lambs. Of the other antibiotics tetracycline was the most commonly sold and was one of the most frequently observed resistances. Although the exact mechanism of the resistance pattern cannot be determined, it is likely that the continued high sales of tetracycline have driven the high levels of resistance. While progress is being made it is clear that further improvement needs to be made. If pathogens such as *Brachyspira hyodysenteriae* continue to develop resistance there may be serious welfare and financial consequences. A large part of the issue is the current lack of data, as without baseline knowledge of consumption, the success of any future interventions cannot be measured. The VMD will continue to work with industry to explore new methods of recording antibiotic consumption and will implement wider surveillance; this in turn should enable evidence based strategy to be devised in order to preserve antibiotics for veterinary and human use.

Data sources

Sales data

Marketing Authorisation Holders (MAHs) – Currently, in the UK there is no system available to collect and collate data centrally detailing antibiotic use, so as a proxy for use antibiotic sales data are collected. Marketing Authorisation Holders of manufactured antibiotics are mandated to provide the Veterinary Medicines Directorate with total annual sales figures for each antibiotic product sold within the UK. Data are collated, verified and then transported into a bespoke spreadsheet for analysis. The total weight, in tonnes, of each active ingredient sold for each antibiotic is then calculated.

In order to calculate the Population Correction Unit data is supplied by:

Defra Statistics division – The live weight of animals slaughtered for food are calculated by Defra. The population numbers of food producing animals are supplied by Defra via the Agriculture in the UK report.

CEFAS – The annual live weight of fish at slaughter for the UK is supplied by CEFAS (Centre for Environment, Fisheries and Aquaculture Science).

TRACES – Import and export figures obtained from TRACES are provided by European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) and used in the calculation of the PCU.

Resistance data

APHA diagnostic submissions – Private veterinary surgeons or farmers in England and Wales can submit carcasses and other diagnostic samples to the Animal and Plant Health Agency (APHA) regional laboratories for diagnostic investigation. Where it is clinically relevant, culture and antibiotic sensitivity testing is carried out on selected isolates from diagnostic samples. The results of such sensitivity tests are compiled; providing data for the "scanning surveillance" element of the AMR surveillance programme.

National Control Program for *Salmonella* in poultry – In order to comply with the requirement of the Zoonoses regulation (EC) No 2160/2003 the UK conducts a National Control Program (NCP) for *Salmonella* in poultry. Under the NCP samples are required to be taken from flocks according to the criteria stated in the Control of *Salmonella* in Broilers, Poultry and Turkeys Orders.[5] [6] The first isolate of each *Salmonella* serovar that is received from an animal or group of animals from one holding is tested for antibiotic susceptibility; the results of this sensitivity testing are presented in the *Salmonella* section page 57.

The Zoonoses Order (1989) – In accordance with the Zoonoses Order of 1989[7] any laboratory isolating *Salmonella* from domestic livestock in Great Britain (GB) is required to notify the Defra, and to submit the isolate(s) to APHA for examination. *Salmonella* isolates submitted in compliance with this order are presented in the *Salmonella sections* (page 57).

The Pig Abattoir Study (OZ0150) – In 2013 a structured abattoir study was commissioned in the United Kingdom (UK) to estimate the prevalence of a range of different diseases in pigs. Caeca from 637 pigs were collected at highest throughput abattoirs, i.e. those slaughtering, in total, 80% of all finishing pigs in the UK. The study design was consistent, where possible, with the technical specifications for the previous EU monitoring scheme for *Salmonella* in slaughter pigs (Commission Decision 2006/668/EC). The prevalence of

[5] http://www.legislation.gov.uk/uksi/2009/260/contents/made
[6] http://www.legislation.gov.uk/uksi/2009/3271/made
[7] http://www.legislation.gov.uk/uksi/1989/285/contents/made

Salmonella and ESBL *E. coli* were identified in the study, these isolates, as well as *Campylobacter coli* isolates recovered from porcine caecal samples, were tested for antibiotic susceptibility.

FSA *Campylobacter* Broiler Abattoir Survey (2013) – The Food Standards Agency (FSA) carried out a structured survey in 2013 to identify the prevalence of *Campylobacter jejuni* and *Campylobacter coli* in broiler chicken caecal samples. The sampling was carried out in accordance with EU technical specifications in Commission Decision 2007/516/EC. Antibiotic susceptibility testing was performed on the *Campylobacter* spp. isolates recovered in the study, and the results are presented in page 67.

Data limitations

Sales data

Antibiotic sales data is considered to be an overestimate of use

- Caution must be applied when extrapolating sales figures to represent antibiotic consumption in any given species. The populations of each animal species are an important denominator; the greater the number of animals, the greater the potential need for antibiotic treatment. As a consequence, changes in the volume of sales should be considered in parallel with changes in the UK animal population over the corresponding time period.
- Larger animals will require a larger total volume of antibiotics over a treatment course (similar to human adults needing a greater volume than children); variation in sales of antibiotics may therefore reflect variation in the animal demographic being treated. This is particularly relevant when comparing antibiotic sales/consumption figures between EU Member States which vary significantly in their national animal populations. To try and address this problem the ESVAC (European Surveillance of Veterinary Antimicrobial Consumption) project has developed a Population Correction Unit (PCU), a calculation that estimates the weight of the animal (or group of animals) receiving an antibiotic at the most likely time of administration. This unit now used across EU Member States and is currently the best approximation of consumption, extrapolated from sales data, for changes within a country over time and for comparisons between countries. We have used this form of analysis as the primary approach in this report.
- Sales data does not permit accurate analysis of antibiotic consumption by animal species or production category. Some formulations of antibiotics are authorised with indications for use in more than one species, e.g. pigs and poultry. It is not possible to ascertain from sales data in which species the product was used.
- In addition, sales data in general overestimate use, as not all antibiotics sold will be used. There is natural wastage resulting from pack sizes that do not meet dose need, and from drug expiry.
- The sales data presented in this report do not take into account imports or exports of products. For the purpose of this report it is assumed that all products sold in the UK remain in the UK and nothing is imported.
- Medication sold for use in humans may be used in animals under certain circumstances, according to the prescribing cascade; figures on such use are not included in the data presented.

Population data:

- The food-producing animal population figures presented in this report are based on a single point in time “census”. While these figures can be considered accurately reflective of the total annual cattle population, they are less so for other animal species. The figures are least representative for poultry raised for meat where the total number at any one time only represent a small percentage of the total raised each year. The sheep population also varies significantly pre and post lambing season each year.
- The population figures used in this report vary slightly to those used in the ESVAC report, which means the figures in this report cannot be directly compared with figures from the ESVAC reports.

Resistance data

Scanning Surveillance – APHA diagnostic submissions:

- Isolates that are obtained through the scanning surveillance programme cannot be considered to accurately reflect the bacterial populations present within the general animal populations present in the UK.
- This method of obtaining isolates is considered to be a "passive" form of surveillance; the samples obtained are not randomly selected and are therefore susceptible to bias. For example, geographical proximity of a farm or veterinary practice to a diagnostic laboratory may have an impact on the submission rate of samples; scanning surveillance may therefore over-represent certain geographical areas, and the animal populations within those areas.
- If resistant isolates are not detected by scanning surveillance it cannot be stated that the resistance is not present in the population, i.e. it cannot prove freedom from disease or resistance.
- Veterinary surgeons have the option to submit samples to private laboratories rather than to APHA laboratories. We are not able to determine the proportion of the total number of samples submitted for sensitivity testing in the UK ,that are processed by APHA laboratories, and therefore we cannot know how representative these samples are of total diagnostic submissions.
- It is also possible that the levels of resistance demonstrated by the isolates presented in this report are higher than those seen in the wider bacterial populations present within animals in the UK. Samples are more likely to be submitted from animals that have been unresponsive to initial antibiotic therapy, and thus the isolates recovered may have already been exposed to antimicrobial pressure.
- The treatment history of the animal(s) from which samples were submitted is not currently linked to the resistance profile of each isolate; it is not therefore possible to speculate how the resistance pattern developed or if isolates are epidemiologically linked.
- The report gives details of the number of bacterial isolates that underwent sensitivity testing, not the number of animals from which samples were submitted. Multiple isolates may be recovered from one sample; it is therefore not possible to determine the proportion of the total animal population, from which samples were submitted.
- The diagnostic tests performed on a sample are dependent on the individual case; i.e. isolates of the same bacterial species are not always tested against the same panel of antibiotics. Therefore, if resistance is not detected in one isolate, it may not mean that resistance is not present, just that it was not tested for. This is especially true of commensal organisms which may be resistant to antibiotics but do not lead to clinical disease in the host animal.
- Isolates from companion animals are only examined if there is a public health concern, therefore these species are underrepresented.
- As explained in the Method (page 32), the breakpoints used for determining resistance are those recommended by BSAC (British Society for Antimicrobial Chemotherapy). These were originally determined for human medicine and their use in veterinary medicine is based on the assumption that the concentration of antibiotic at the site of infection is the same in animals as it is in humans**.** Currently it is not known if this assumption is always correct, especially as different dosing regimens may be used in animals and pharmacokinetics may vary between species.
- In the case of some veterinary antibiotic and organism combinations a BSAC cut-off may not exist, in which case a uniform cut-off is used to define resistance. The consequence of this is that some isolates that are considered to be resistant based on BSAC cut off may actually be sensitive in a clinical veterinary setting and vice-versa**.**

Structure of the report

A summary of key findings are provided for antibiotic sales and antibiotic resistance data on pages 10, 11, 12 and 13. Detailed descriptions of the results of each surveillance programme are presented in Chapters 2 and 3. In order to aid navigation around the report, all figures relating to antibiotic sales are presented in **blue** and all figures relating to antibiotic resistance are presented in **red**.

Antibiotic Sales

Antibiotic sales data covers the period 2009-2013. The report initially addresses the sales of antibiotics in the context of the livestock population, presented as volume of antimicrobial sold per Population Correction Unit. This is followed by mg/PCU of active ingredient sold for use in food producing species, and mg/PCU of sales of antibiotic classes considered critically important for human health (the fluoroquinolones, 3rd and 4th generation cephalosporins, and macrolides). Later sections provide information on the volume of intramammary products sold in relation to the UK dairy herd, and the total volume of sales analysed by antibiotic class, route of administration and species. Data for the sales of antiprotozoal and antifungal antimicrobials are included in **Annex 4**.

Antibiotic Resistance

Bacterial resistance data covers the period 2011-2013, presented according to isolate source; "scanning" surveillance (including veterinary pathogenic bacteria, zoonotic bacteria and *E. coli*), *Salmonella* surveillance and structured surveillance.

Within the "scanning" surveillance section, for each bacterial species the total number of isolates identified over the three year period and the number of multi-resistant bacteria are indicated, followed by a written summary which outlines the resistance patterns identified. For the more commonly isolated bacteria, (>20 isolates/year), the data are also presented in graphical form. Antibiotic panels are selected according to clinical relevance and may vary with each case; as a result isolates may not have been tested against certain antibiotics. The isolates presented in the graphs are therefore subdivided in to three groups, susceptible, resistant and not tested. Tables of data for all bacterial species identified can be found in **Annex 5**. *E. coli* data are presented by age group, (neonatal, pre weaning and adult) due to the marked variation in resistance seen in bacteria obtained from each group. Additional information is presented in text boxes throughout the resistance chapters.

The *Salmonella* surveillance data covers all *Salmonella* isolates, from a range of sources. *Salmonella* differs from other bacteria as a national control programme is in place (in flocks of broilers, layers, breeders, and turkeys in the UK) to reduce the prevalence of this pathogen, consequently surveillance for this pathogen is enhanced.

Finally, we present the results of the structured surveys that were carried out to investigate the prevalence of resistance in isolates of *E. coli, Campylobacter* and *Salmonella* from poultry and pigs.

Future plans for data collection

Consumption data – As described above, antibiotic sales data as a proxy for use holds many limitations. The VMD is currently investigating options for the collection of antibiotic consumption data in food producing animals. The VMD is currently participating in the protocol development stages of an ESVAC project to collect farm level consumption data from the pig sector. This programme will be extended in 2015, and further rolled out to look at antibiotic consumption in the poultry and cattle sectors over the next three years. At a national level, the VMD is also working alongside the livestock industry to investigate and facilitate options for collecting accurate antimicrobial usage data.

One health – Currently human consumption data are reported separately to veterinary data and are calculated as DDDs (Defined Daily Doses). The VMD has collaborated with ESPAUR (English Surveillance Programme for Antimicrobial Utilisation and Resistance) and a combined report is planned for 2015.

Resistance data - As described above there are numerous limitations to using scanning surveillance. In order to provide improved antibiotic resistance surveillance, in compliance with expanding European monitoring requirements, the following programmes of surveillance have been established.

- *Campylobacter jejuni* from fattening turkey and broiler caecal samples at slaughter
- *E. coli* from fattening turkeys and broiler caecal samples at slaughter

The first results from these surveys will be published in 2015.

Chapter 2 – Sales of Antimicrobial Products Authorised for use as Veterinary Medicines

ANTIBIOTIC SALES IN THE CONTEXT OF LIVESTOCK AND ANIMAL DEMOGRAPHICS

Adoption of the European Population Correction Unit (PCU)

When assessing antibiotics sales it is important that the demographics of the animal population potentially exposed to treatment are also taken in to account, (see "data limitations"). **Table 1** shows the population of food-producing animals recorded each year in Defra's June Census for each of the last five reporting years. All figures are quoted in thousands of individual animals and are not adjusted for seasonality.

Table 1: Numbers of Livestock (in 000s) in 2009–2013 by species

	2009	2010	2011	2012	*2013
Cattle	10025	10112	9933	9900	9844
Pigs	4540	4460	4441	4481	4885
Sheep	31445	31084	31634	32215	32856
Poultry	152753	163867	162551	160061	162609**

2012 Data have been validated since the previous report.

*2013 Data are provisional as they have not been fully validated at the time of printing.
**Census data is likely to be a large underestimate of the poultry population.

It is also necessary to take into account the varying weight of different animal species and the weight of each particular species at the time when they are most likely to have been treated with antibiotic products, since this is likely to be different to their weight at the time of slaughter. This is achieved through use of the PCU, a technical unit of measurement representing the estimated weight at treatment of livestock and slaughtered animals (1 PCU = 1 kg of different categories of livestock and slaughtered animals). The annual ESVAC (European Surveillance of Veterinary Antimicrobial Consumption) report uses the PCU in order to estimate temporal trends in use or sales of antibiotics across different EU Member States. The PCU figures used in the analysis below are taken from the ESVAC scheme.

The PCU for each reported animal category was calculated by multiplying the total number of each category of livestock animals in the UK (see foot-note to **Table 2**) by their theoretical weight at the age when antibiotic treatment is most likely to take place. The calculation takes into account animals exported from the UK for slaughter, or imported to the UK for fattening. Full details on the methodology of calculation of the PCU can be found in the 2009 ESVAC report, as can the average weight of each category of animal at treatment, as used in the PCU calculation.[8]

The figure included for pigs and poultry is a combined one, since the bulk of UK antibiotic products sold are authorised for use in both species and it is not possible to accurately apportion the amount sold for use in each separately. Individual values for sheep and fish are not shown because the total amount of antibiotics sold for these species is small (less than three tonnes), (see section on antibiotic sales data; **Table 8**). Companion animals are not included in the PCU as reliable population data cannot be collected, therefore antibiotic products authorised for use in both food and non-food animals are not included in the analysis.

[8] http://www.ema.europa.eu/docs/en_GB/document_library/Report/2011/09/WC500112309.pdf

It is important to note that there are still limitations to this additional analysis, since it does not take into account changes in population size throughout the year e.g. for species such as poultry the figure provided is likely to be an underestimate. However, use of the PCU is a further step towards more accurately demonstrating the weight of active ingredient sold per kg of food producing animal population. The analysis in this report is more detailed than that included in the ESVAC report, including analysis at the level of active ingredient (**Annex 2**).

Analysis of Sales by Animal Species PCU

Table 2 states the calculated PCU value for all food producing species together with a breakdown of that total into cattle and combined pig and poultry PCU values. **Figure 1** shows the amount of antibiotic sold in the UK for use in all food producing species, in cattle and in pigs and poultry combined, normalised using the PCUs for 2008- 2013. **Figure 2** shows the sales of critically important antibiotics, also normalised using PCUs.

Table 2: Population correction unit (PCU) per 1,000 tonnes 2008-2013

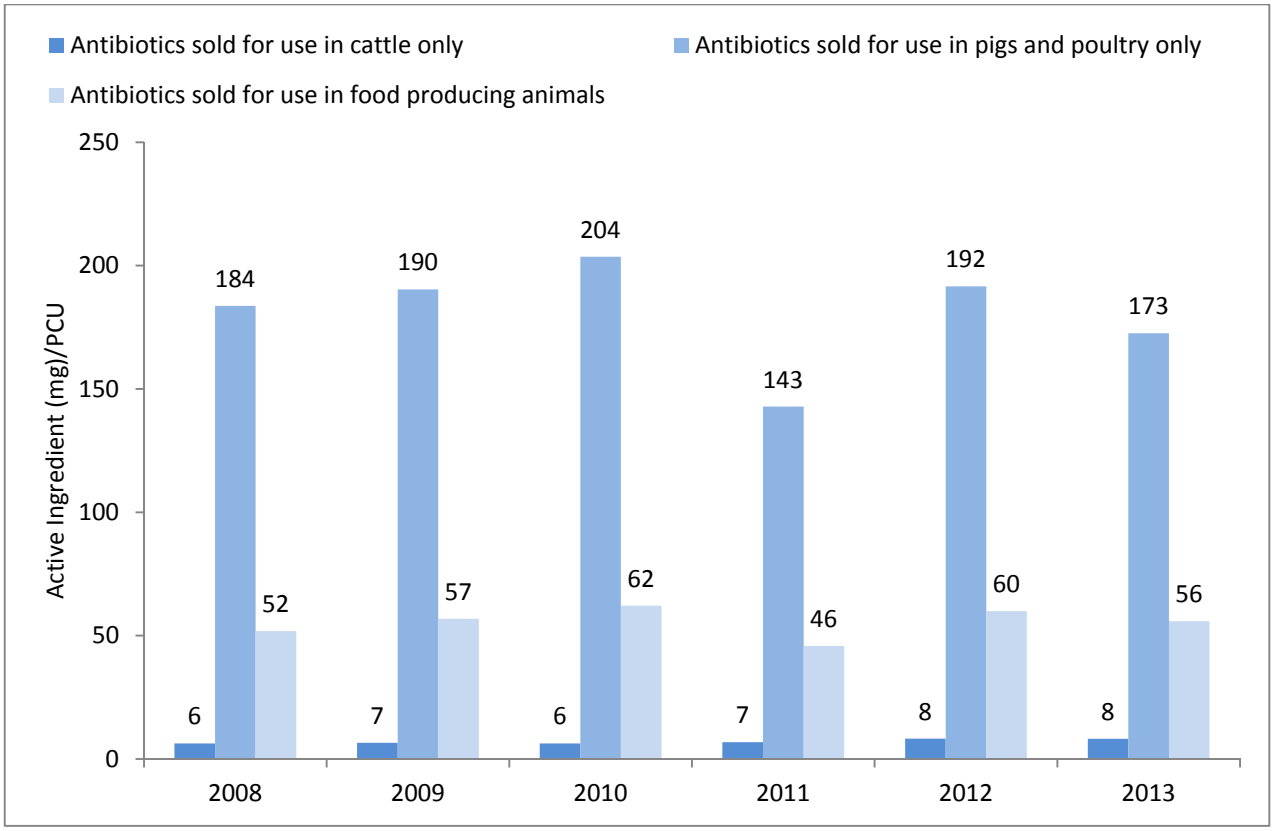
	2008**	2009**	2010	2011	2012	2013*
Total food producing species PCU (excluding horses)[1]	6328	6145	6275	6330	6354	6357
- Cattle only PCU	1757	1678	1750	1767	1708	1709
- Pigs and poultry only PCU	1568	1597	1714	1729	1733	1773

[1] Total food producing species PCU includes cattle, pigs, sheep, goats, poultry (broilers) and fish.

*PCU calculation for 2013 is based on import/export figures obtained from TRACES and EUROSTAT provided by ESVAC and Defra census data; these have not yet undergone full ESVAC validation process and therefore are provisional. Data from 2012 have undergone validation and have been updated since the previous report.

***NOTE:** The PCU figures for 2008 and 2009 have been updated since the 2012 UK-VARSS report. The PCU published in UK VARSS-2012 for the years 2008 and 2009 were calculated for the first ESVAC report, from Eurostat and TRACES data, before the implementation of the 2010 ESVAC protocol and data collection form, and as such UK national statistics were not used to validate the calculation. The PCU statistics for 2010 onwards have undergone national validation and in some cases amendments have been made. The ESVAC project team do not intend to revise the PCU data prior to 2010; however these figures have been revised for this national report based on the variations between Eurostat and national data for the numbers of live sheep.*

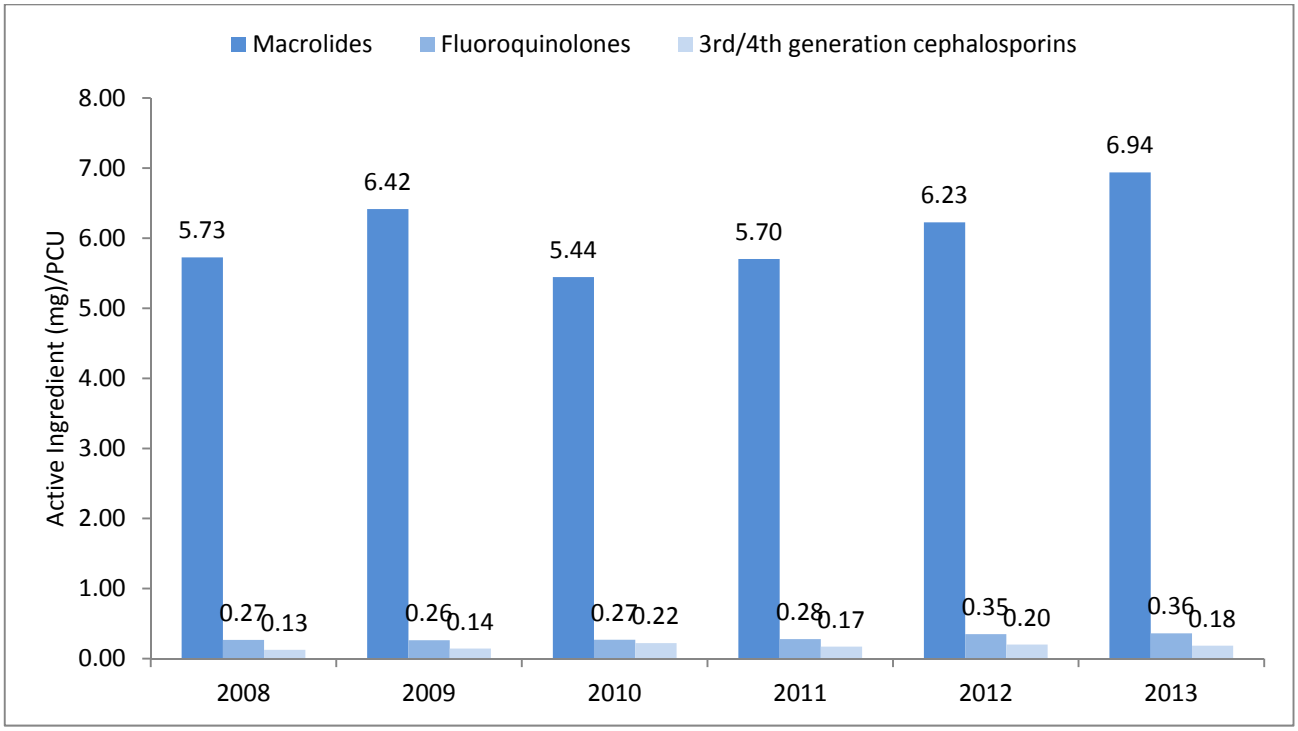
Figure 1: Milligrams (mg) of active ingredient sold for food producing animals per population correction unit (PCU) 2008-2013



The sales for all food producing species equated to 56 mg/PCU in 2013, this was a reduction from 60mg/PCU in 2012. The mg/PCU figure for all food producing species was relatively stable between 2008 and 2013 and the average (mean) for the six year period was 55.5mg/PCU/year. There was an increase in 2010 with a sharp decrease in 2011, this pattern has been discussed in previous reports and details are provided in **UK-VARSS 2012**. When comparing the mg/PCU figures between species it can be seen that significantly smaller quantities of active ingredient were sold per kg for use in cattle than in pigs/poultry. This variation suggests that different quantities of antibiotic are used in the production of different food animal species, and may reflect a number of factors including production type, husbandry, and disease prevalence[9]. However, it must be noted that the PCU calculation for pigs/poultry does not include figures for egg producers (laying hens) and therefore is likely to be an overestimation. This variation demonstrates the value of performing further analysis of sales data at a species level.

[9] Information on changes in livestock disease patterns that may have influenced sales of antimicrobials can be found in Defra funded disease surveillance reports available at:
http://www.defra.gov.uk/APHA-en/category/publications/disease-surv/surv-reports/

Figure 2: **Milligrams (mg) of active ingredient of critically important antibiotics sold for food producing animals per population correction Unit (PCU) for 2008-2013**



Analysis of sales of the active amount of critically important antibiotics (CIAs) authorised for use in food producing only species, in the context of PCU, is shown in **Figure 2**. This analysis excludes fish since there are no products containing CIAs authorised for use in fish, and therefore inclusion of these species within the PCU figure would artificially skew the results. All values are low, with none for the macrolides exceeding 10 mg/PCU, and the fluoroquinolones and 3rd and 4th generation cephalosporins all below 0.5 mg/PCU. Even if the analysis is widened to include antibiotic products authorised for food and non-food animals, the maximum impact for any year is an increase of 0.33 mg for macrolides and 0.03 mg for the other CIAs (data not shown).

Analysis of Intramammary Products Sales by UK Dairy Herd

For the second time we have included this year a more detailed analysis of the trend in sales of intramammary antibiotics according to the size of the UK dairy herd, in order to place sales of these products in greater context.

Sales of intramammary products varied in number between 10.1 and 11.8 million tubes across the period 2009-2013 (**Table 3**). Sales of products for lactating cows decreased by 1.3 million tubes and sales of dry cow therapy products decreased by 0.4 million tubes between 2012 and 2013.

The content of antimicrobial active ingredient(s) contained within different intramammary products varies both in the number of ingredients and the quantity of each active ingredient.

Table 3: Sales in kg of active ingredient and (millions of tubes) of antibiotic intramammary products 2009-2013

	2009	2010	2011	2012	2013
Dry Cow Products	1873 (4.8)	1882 (5.2)	1686 (4.6)	1885 (5.1)	1593 (4.7)
Lactating Cow Products	1298 (6.0)	1649 (6.1)	1400 (5.5)	1720 (6.7)	1163 (5.4)
Total	3171 (10.8)	3531 (11.3)	3086 (10.2)	3605 (11.8)	2756 (10.1)

Sales of intramammary products vary between 2,756 and 3,605 kg of active ingredient over the 5 year period (**Table 3**). There was a decrease in sales between 2012 and 2013. Sales of lactating cow products decreased to 1,163 kg in 2013 and sales of dry cow therapy products decreased to 1,593 kg.

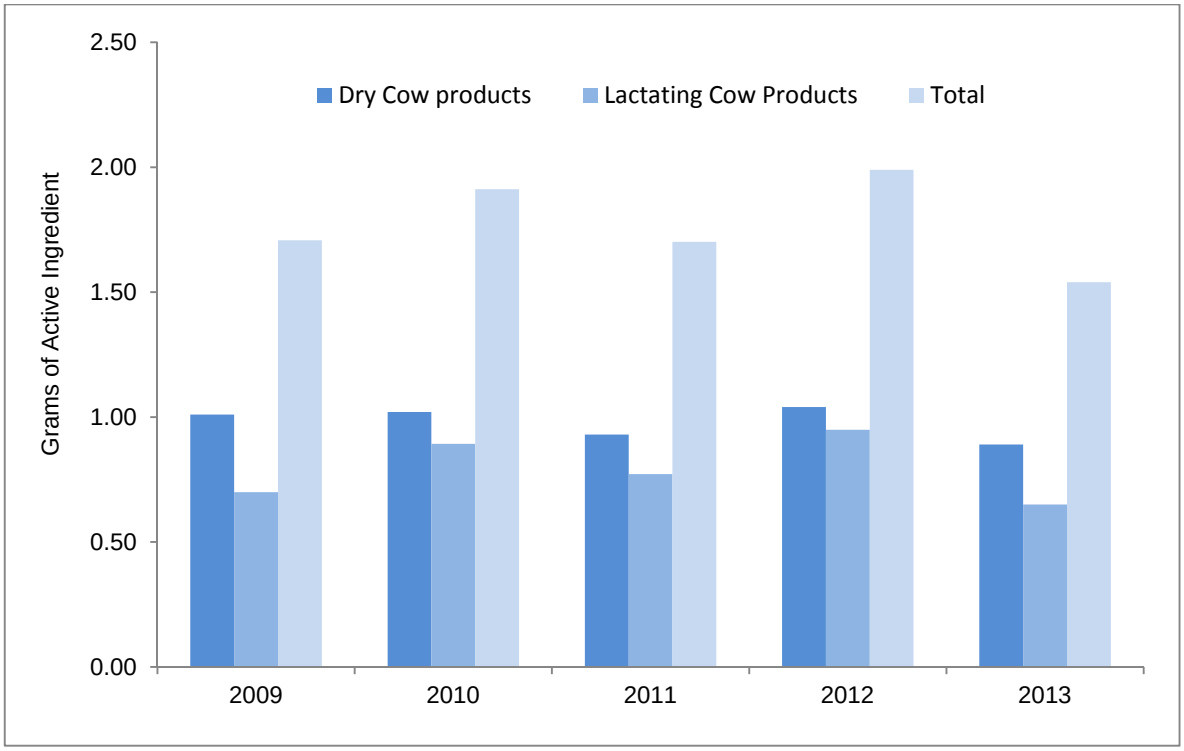
Sales of active ingredient administered by the intramammary route have been analysed in respect to the size of the national dairy herd (**Table 4 & Figure 3**). Overall the sales from 2009 to 2013 for lactating and dry cow products remained stable, ranging between 1.54 g and 1.99 g average per dairy cow.

Table 4: Sales (grams active ingredient) of antibiotic intramammary products per dairy cow in the national herd 2009–2013

	2009	2010	2011	2012	2013
Number of dairy cows in the national herd (thousand head)	1857	1847	1814	1812	1782
Dry Cow Products	1.01	1.02	0.93	1.04	0.89
Lactating Cow Products	0.7	0.89	0.77	0.95	0.65
Total	1.71	1.91	1.70	1.99	1.54

N.B. National beef herd were not included in this analysis.

Figure 3: Sales of antibiotic intramammary products (grams active ingredient) per dairy cow in the national herd 2009–2013



Total Sales and Sales by Antibiotic Chemical Group for Food and Non-Food Animals

The total quantities of antibiotic active ingredient in products sold between 2007 and 2013 are shown in **Table 5**, as is their breakdown by chemical grouping. The trend in overall sales over the reporting period is distorted by the data for 2010 and 2011. The rise in sales seen in 2010 is likely to be due to changes in Marketing Authorisation Holder for a small number of food-producing animal products between 2010 and 2011 leading to stockpiling in 2010 (due to concerns about availability) and consequential lower purchasing during 2011; because of this anomaly in the sales trend, totals for the past seven years are shown in **Table 5** in order to provide five "normal" sales years. Across these years, 2007-2009 and 2012-2013, there has been no consistent pattern, with a variation of 14% between the highest and lowest sales years, although 2010 was the highest at 11% above the 7 year mean.

Table 5: Sales (tonnes active ingredient) of total antibiotic products by chemical grouping 2009 –2013 and total sales 2007-2013

	2009	2010	2011	2012**	2013
Tetracyclines	177	200	110	190	184
Trimethoprim/ Sulphonamides	73	75	72	80	61
ß-lactams	76	93	86	90	89
Aminoglycosides	19	22	19	20	21
Macrolides	39	35	37	41	43
Fluoroquinolones	2	2	2	2	3
Other	16	20	20	21	19
Total (2007=387, 2008=383)	402	447	346	445	420
Fluoroquinolones	1,849	2,232	2,085	2,434	2,610

** ***NOTE:*** *The quantities of antibiotic active ingredient in products sold in 2012 have been updated since last year's report (**UK-VARSS 2012**). This is due to a resubmission of 2012 data by a Market Authorisation Holder. More details on the amendments can be found in **Annex 3**. The revised 2012 data have been included throughout the report*.

The sales of various chemical groups of antibiotics between 2007 and 2013 are shown in **Table 5** and **Figure 4.** These represent the main chemical groups of veterinary antibiotics sold in the UK. Definitions of these groups can be found in the "Glossary of Terms" at **Annex 7**. In all years, tetracyclines, ß-lactams (including penicillin) and trimethoprim/sulphonamides have accounted for the majority of antibiotic active ingredients sold in veterinary medicinal products. In 2013, these groups accounted for 80% of sales, (7% lower than 2012), with tetracyclines accounting for 44%, ß-lactams 21% and trimethoprim/sulphonamides 15%. The majority of tetracycline products sold were authorised for use in cattle, pigs and poultry.

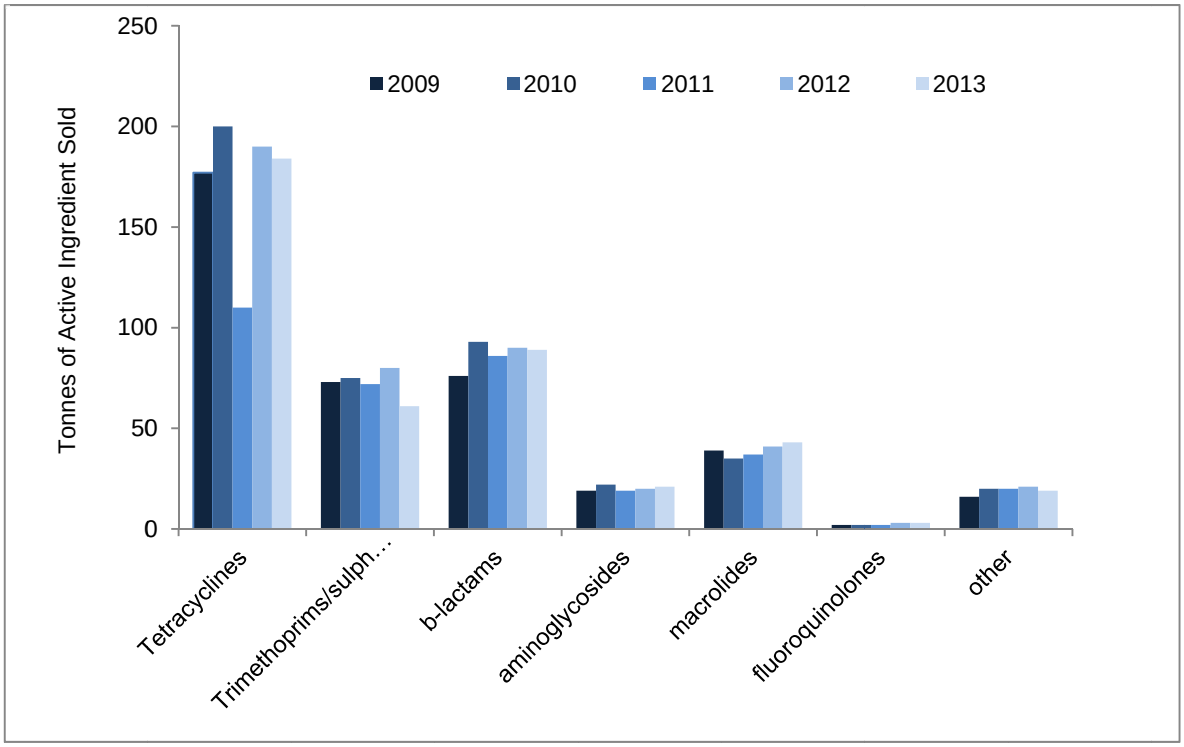
Table 5 and **Figure 4** indicate a fairly stable trend in the sales of aminoglycosides, fluoroquinolones and "other" antibiotics over the past 5 years. Sales of trimethoprim/sulphonamides and ß-lactams have fluctuated over the same period, with sales of both classes declining in 2013 compared to 2012. Tetracycline sales have also fluctuated over the 5 year period, with the greatest variation observed between 2010 and 2011. A further increase in sales of tetracycline products occurred in 2012, with a subsequent decrease of six tonnes in 2013. There was an increase in sales of macrolides in 2013 for the third consecutive year.

Because of particular interest in fluoroquinolones the actual figures in addition to the rounded figures are shown.

The data supplied to the VMD indicate that the increase in fluoroquinolone sales in 2013 was due to increased sales of a single product indicated for use in poultry.

Data provided by the British Poultry Council revealed that usage of fluoroquinolone products in the commercial poultry meat industry contributes to 0.53% of sales of fluoroquinolone products authorised for use in poultry only, this would suggest that a large proportion of fluoroquinolones indicated for use in poultry are not being used in commercial meat production.

Figure 4: Sales (tonnes active ingredient) of total antibiotic products by chemical group 2009–2013



The European Commission released several publications[10] in 2011 and early 2012, acknowledging the need to formulate a shared European definition of Critically Important Antimicrobials (CIAs) for humans and animals, using World Organisation for Animal Health (OIE) and World Health Organisation (WHO) definitions as a basis.

In November 2007, the Joint FAO/WHO/OIE Expert Meeting on CIAs developed 11 recommendations to address the risk analysis process of hazards related to antimicrobial resistance resulting from the use of antimicrobials in food animals. Recommendation 7 stated:

[10] (1) EC,15.11.2011, Action plan against the rising threats from Antimicrobial Resistance, (16939/11); (2) EC, 01.06.2012, The impact of antimicrobial resistance in the human health sector and in the veterinary sector – a "One Health" perspective; Information from the Presidency, (10582/12)

"Foodborne pathogens and commensals, (in particular *Salmonella* spp., *Campylobacter* spp. and *Escherichia coli*), linked to the potential antimicrobial resistance to 3rd and 4th generation cephalosporins, quinolones and macrolides should be given special consideration for risk analysis".

Of these three groups of antimicrobials, the data from 2013 show that there were 1.2 tonnes of 3rd and 4th generation cephalosporins sold compared to 1.3 tonnes in 2012. This equates to the same percentage of total sales in 2011, 2012 and 2013 (0.3%). In 2013 fluoroquinolones accounted for 0.6% of total sales at 2.6 tonnes, an increase from 2.4 tonnes in 2012; macrolides accounted for 10% of total sales at 43 tonnes compared to 41 tonnes in 2012. The overall percentage of total sales by CIAs has remained similar in 2013 to 2012, as has the actual weight of active ingredient sold.

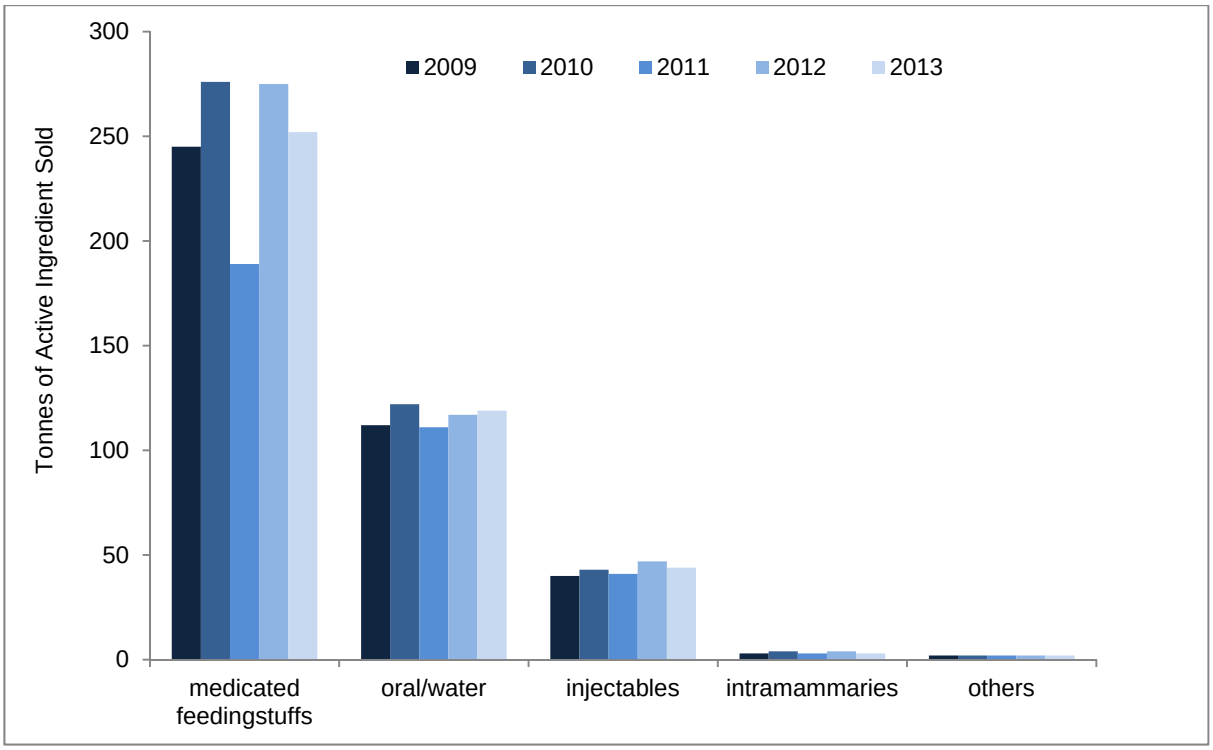
Sales by Route of Administration

The major routes of administration of antibiotics sold in 2009–2013 are listed in **Table 6** and **Figure 5**. Of the antibiotics sold in 2013, medicated feeding stuffs and oral/water soluble accounted for 60% and 28.3% respectively. Injectable, intramammary, and other antibiotic products (creams, aerosols, drops etc.) contributed 10.5%, 0.7% and 0.5% respectively.

Table 6: Sales (tonnes active ingredient) of total antibiotics by route of administration 2009–2013

	2009	2010	2011	2012	2013
Medicated Feeding stuffs	245	276	189	275	252
Oral/Water	112	122	111	117	119
Injectable	40	43	41	47	44
Intramammary	3	4	3	4	3
Others	2	2	2	2	2
Total	402	447	346	445	420

Figure 5: Sales of total antibiotics (tonnes active ingredient) by route of administration 2009–2013



*

Others include aerosols, creams, and ear and eye medications.

Sales by Animal Species Indication

The quantities of antibiotic active ingredients in products sold between 2009 and 2013 are expressed graphically in **Figure 6** and shown in detail in **Table 7**, to the level of sales for use in food-producing animals only, non-food-producing animals only, and for use in either. They are expressed as tonnes of active moiety.

Figure 6: Sales for animal use of antibiotic products (tonnes active ingredient) 2009–2013

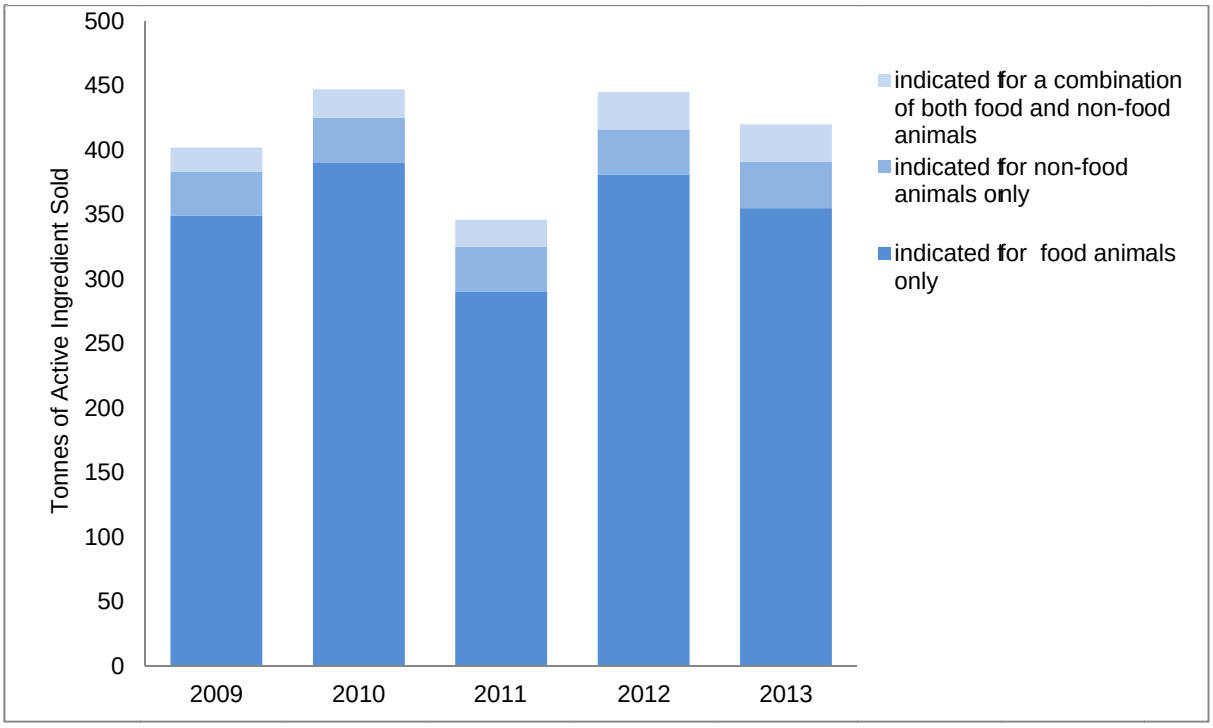


Table 7: Sales (tonnes active ingredient) of antibiotics 2009–2013, in the categories of food animals only, non-food animals only and combined food and non-food animals

	2009	2010	2011	2012	2013
Indicated for food animals only	349	390	290	381	355
Indicated for non-food animals only	34	35	35	35	36
Indicated for a combination of both food and non-food animals	19	22	21	29	29
Total sales of antibiotics	402	447	346	445	420

Sales of veterinary antibiotics for use in non-food-producing animals have remained stable over the period 2009 to 2013, selling between 34 and 36 tonnes; sales of products for use in either food-producing or non-food-producing species has remained stable between 2012 and 2013 at 29 tonnes.

The breakdown of the sales of antibiotics in products authorised only for food animals is shown in **Table 8**. In 2013, 86% of active ingredient from antibiotic products authorised only for food animals were for use in a combination of pigs and poultry. Other multi-species products are authorised for use in more than one food-producing animal and do not include “pig and poultry only” products. These accounted for 9.5% of sales of antibiotics sold for food producing animals in 2013.

Table 8: Sales (tonnes active ingredient) of total antibiotics for food-producing animals only by species 2009–2013

	2008	2009	2010	2011	2012	2013
Cattle Only Products	11	11	11	12	14	14
Pig Only Products	62	62	47	62	65	61
Poultry Only Products	31	37	50	23	22	19
Sheep Only Products	<1	<1	<1	<1	<1	<1
Fish Only Products	1	3	1	2	2	1
Pig and Poultry Combined Only	195	205	252	162	245	226
Other Multi Species Products in Food Animals Only	28	31	29	29	33	34
Total	328	349	390	290	381	355

We are currently exploring alternative methods of data collection to permit a more accurate analysis of antibiotic consumption by animal species and production type, in particular for pigs and poultry (see “Future plans for data collection”).

Chapter 3 – Antimicrobial Resistance

Method

The susceptibility tests described in this report were performed (unless otherwise stated in the report) using a disc diffusion technique on Isosensitest Agar (Oxoid) with appropriate media supplementation where necessary for fastidious organisms. The disc concentrations used are as stated in **Annex 6** and a semi-confluent inoculum is used in the test procedure. The method used is identical to that recommended by the British Society for Antimicrobial Chemotherapy (BSAC)[11]. Where published breakpoints are available from BSAC then these have been used for the interpretation of the veterinary antibiotic susceptibility results. It is important to note that this assumes that the level of antibiotic achieved at the site of infection in the animal is similar to that achieved in a human treated with the same antibiotic; of course this assumption may not always be correct, not least because different concentrations may be achieved at the site of infection in animals as a consequence of different dosing regimens or the result of differing pharmacokinetics in different animal species.

Isolates have been classed as either sensitive or resistant; intermediate isolates under the BSAC guidelines are considered resistant. The disc diffusion breakpoints used are given at **Annex 6** which also provides the MIC corresponding to that zone diameter breakpoint where this is known or has been estimated from data on file.

For some veterinary antibiotic and organism combinations, there are no published breakpoints available using either the BSAC method or other methods. Published breakpoints are therefore not available for all animal species and for all of the bacterial organism/antibiotic combinations which may require testing. In these cases, a uniform cut-off point of 13mm zone size diameter has been used to discriminate between sensitive and resistant strains; an intermediate category of susceptibility has not been recorded. This breakpoint is the historical APHA veterinary breakpoint and although it has been used for a considerable number of years, published validation data are not available for a number of organism/antibiotic combinations. However, it is pertinent to note that where the majority of isolates of a particular organism are highly resistant or fully susceptible to an antibiotic, breakpoint issues can affect a surprisingly low number of isolates (or no isolates).

It is intended to accumulate data on disc diffusion zone sizes obtained and, when available, relevant MIC data to try to refine breakpoints where data are currently lacking. The zone size diameter of organisms collected using current methods is also being used to investigate epidemiological cut-off values (microbiological breakpoints) by establishing the normal distribution of the wild type population and looking for deviation from this population. These procedures (disc diffusion zone size and MIC determination and establishment of the wild type population) are being used to look at and review the performance of current methods when susceptibility testing veterinary organisms as further data accumulates. Those antibiotic/organism combinations which have been assessed thus far are shown in **Annex 6**, which also shows the breakpoints used and the equivalent MIC where this is known.

Multiple antibacterial resistance is defined in this report as resistance to any four or more of the antibiotics which were tested for a particular isolate. There is no internationally agreed definition of multiple resistance and the term has been used differently in various studies (Schwarz *et al*. 2010, EFSA 2012). The panels of antimicrobials which may be tested at a particular APHA laboratory can also show slight variation, dependent on the circumstances of the case and the requirements of the veterinary surgeon administering

[11] www.bsac.org.uk

treatment. The multiple resistance figures should therefore be regarded as subject to a degree of variation; they also consider resistance to each different antibiotic as a “separate” resistance.

A network of APHA veterinary laboratories performed the susceptibility tests. The laboratories are situated throughout England and Wales with one laboratory in Scotland. All APHA regional laboratories contributed a full dataset for 2010 and 2011. Data for 2009 comprises the data collected in that year from the point of introduction at each particular regional laboratory of an automated zone reader.

Scanning Surveillance

Veterinary Bacteria

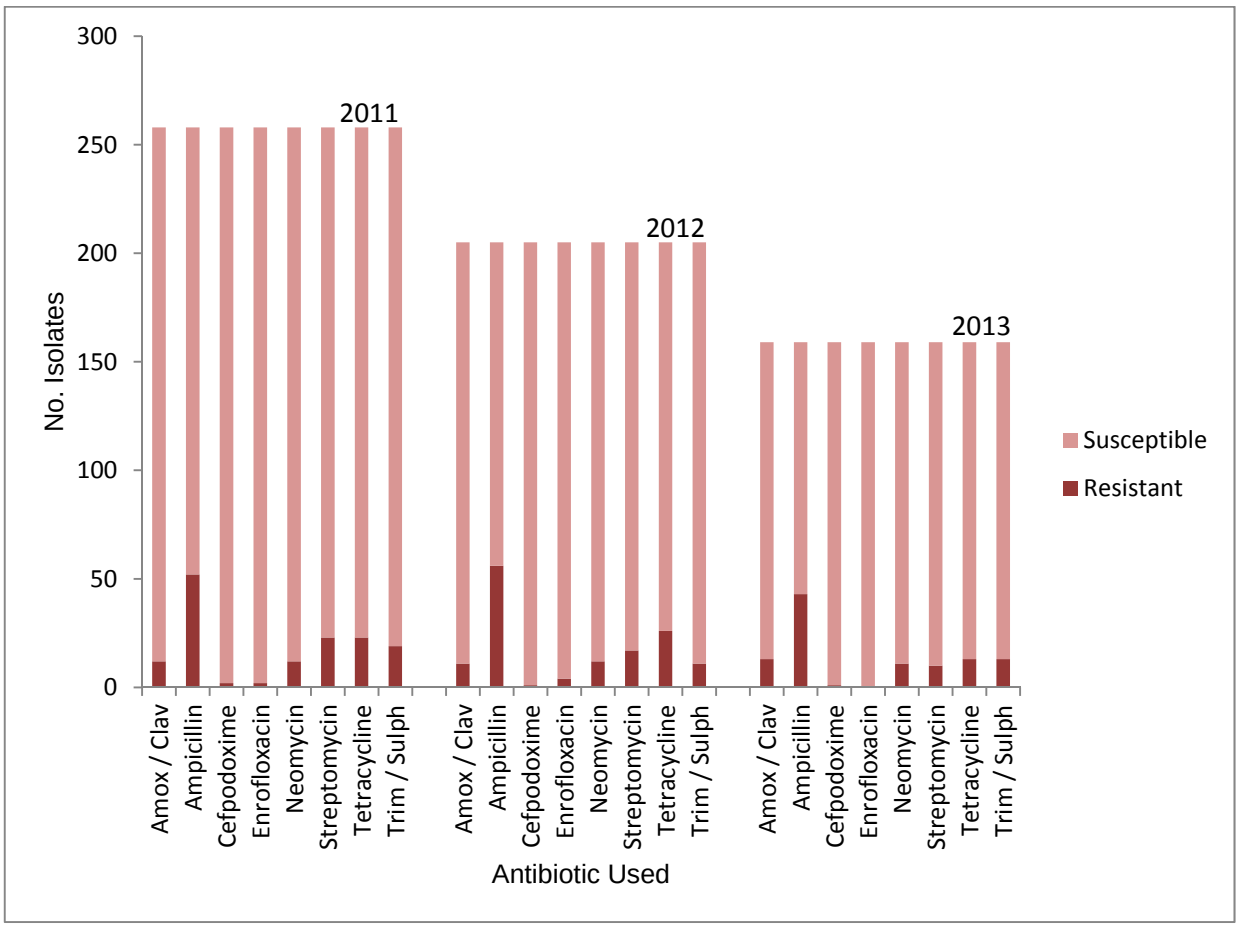
Mastitis causing pathogens – Gram-negative organisms (Cattle)

E. coli/coliforms (mastitis only)

622 isolates were identified; multiple resistance was seen in 7% in 2011, 5% in 2012 and 8% in 2013. Data are displayed in **Figure 7**. The greatest resistance seen was to ampicillin with up to 27% of isolates being resistant each year. Resistant isolates occurred for each antibiotic but resistance to cefpodoxime and enrofloxacin was seen least frequently.

E. coli and other coliforms are one of the three main causes of bovine mastitis. Most strains originate from the immediate environment of the cow and it is thought that no special virulence factors are required to infect the mammary gland. These isolates therefore represent the normal types that are present in the environment of adult dairy cattle, particularly cattle sheds and cubicle houses, and are probably mainly of faecal origin.

Figure 7: Susceptibility of *E. coli* mastitis isolates in cattle 2011-2013



Klebsiella pneumoniae

23 isolates were identified over the three year period (**Annex 5**). Resistance to ampicillin occurred in a total of 65% of isolates. In 2011 and 2012 there was no resistance to any other antibiotics, but in 2013 there was at least one resistant isolate for every antibiotic apart from enrofloxacin.

Klebsiella pneumoniae is intrinsically resistant to ampicillin.

Pseudomonas aeruginosa

18 isolates were identified over the three year period (**Annex 5**), multiple resistance was not observed. All of the isolates that were tested were resistant to amoxicillin/clavulanic acid, ampicillin, cefpodoxime and cephalexin. 88-94% were resistant to tetracycline and trimethoprim sulphonamide. No resistance was seen to ceftazidime or streptomycin. In 2013 no resistance was seen to cefotaxime or enrofloxacin, but resistance to both had been seen in previous years.

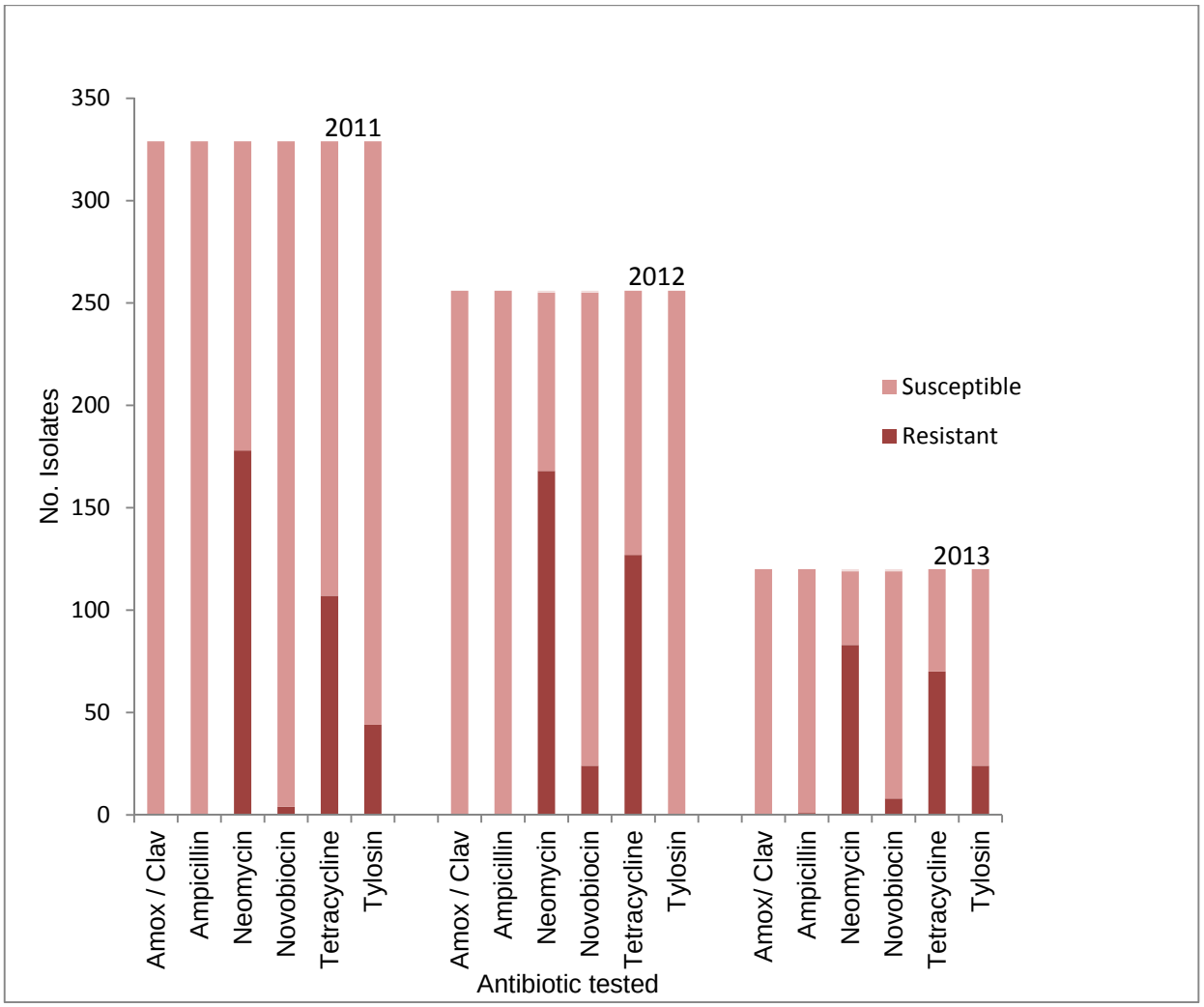
Mastitis causing pathogens – Gram-positive organisms (Cattle)

Streptococcus uberis

705 isolates were identified over the three year period; multiple resistance did not occur in 2011 but was seen in 2% of isolates in 2012 and 3% of isolates in 2013 (**Figure 8**) Greatest resistance was seen to Neomycin; increasing from 54% of isolates in 2011 to 70% of isolates in 2013. Resistance to tetracycline was seen in 58% of isolates in 2013, an increase from 33% in 2011. Resistance to tylosin also increased over the three years from 13% to 20%. Resistance to novobiocin peaked in 2012 at 9%. No resistance was detected to amoxicillin/clavulanic acid. A single isolate (1%) was resistant to amoxicillin in 2013; no resistance had been detected to amoxicillin prior to 2013.

Macrolide resistance can be mediated by the induction of a plasmid-encoded enzyme which methylates the 20S ribosomal RNA sub-unit and prevents binding of the macrolide to the ribosome and so disrupts protein synthesis. However, the exact mechanism of resistance has not been elucidated in the isolates recorded here.

Figure 8: Susceptibility of *Streptococcus uberis* mastitis isolates in cattle 2011-2013



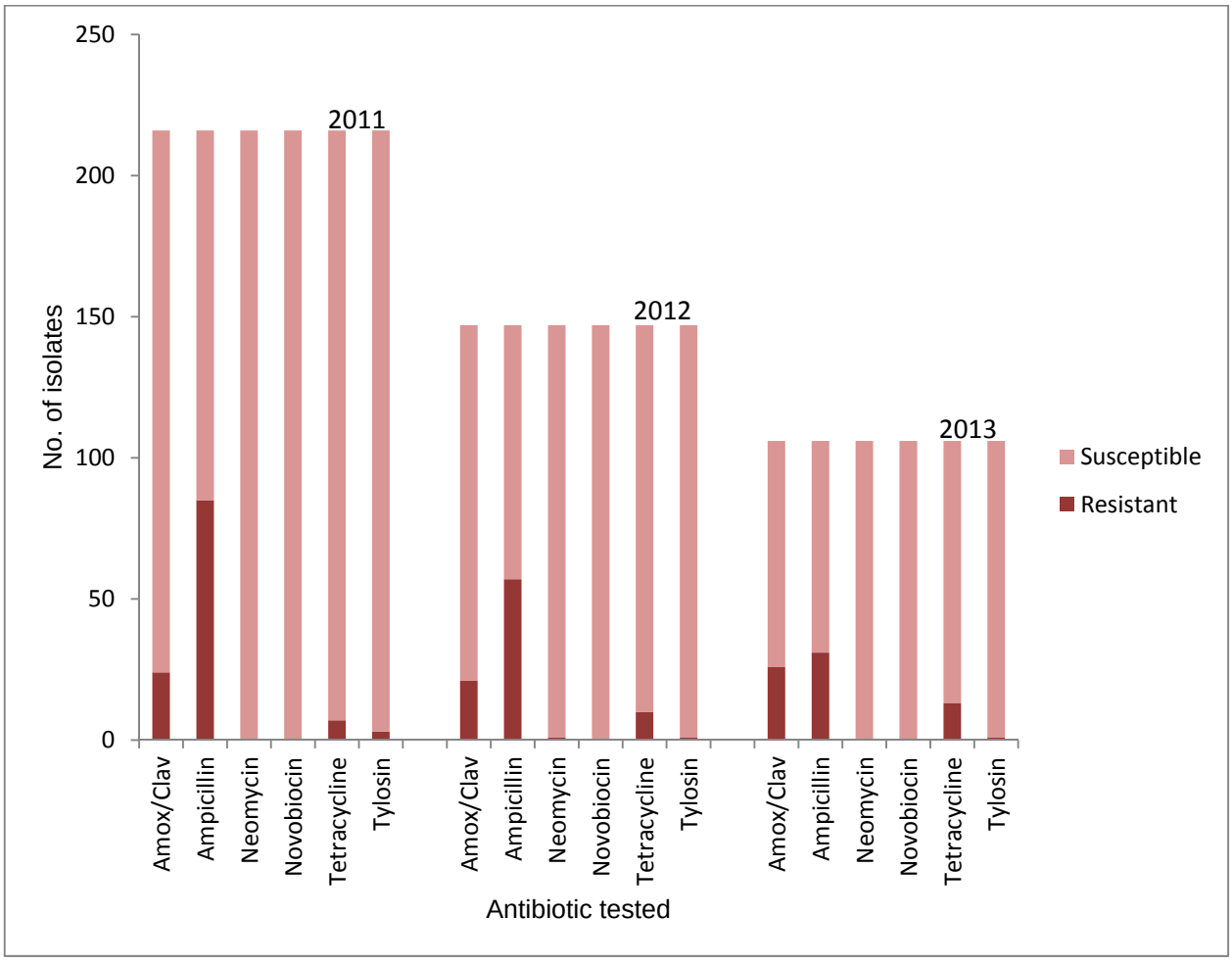
Staphylococcus aureus

469 isolates were identified over the three year period, multiple resistance was seen in 1% in 2011, 4% in 2012 and 6% in 2013 (**Figure 9**). Highest levels of resistance were seen to ampicillin, with 39% of isolates being resistance in 2011 and 2012; in 2013 the figure decreased to 29%. Resistance was also detected to amoxicillin/clavulanic acid, the percentage of resistant isolates increased each year to 25% in 2013. It should be borne in mind that the total number of isolates decreased each year; the number of isolates resistant to amoxicillin/clavulanic acid stayed fairly static but due to the decrease in the number of samples submitted the overall percentage resistance increased. Tetracycline resistance was seen in a maximum of 12% of isolates and appeared to be increasing over the three year period. Resistance to tylosin was detected in 1% of isolates each year.

Penicillin resistance in bovine *S. aureus* is thought to occur mainly via the production of beta-lactamases that degrade both penicillin and ampicillin. The genes encoding beta-lactamases can be located on plasmids and often on transposons and may be readily transferable by conjugation. *S. aureus* isolates resistant to ampicillin are currently screened for susceptibility to cefoxitin in order to detect the variant *mecA* gene (now described as *mecC*) as well as isolates of classical MRSA. No MRSA isolates were detected by scanning surveillance in cattle over the period 2011-2013. The variant *mecA* gene *mecC* was recently described in bovine *S. aureus* isolates from the UK (García-Álvarez *et al*. 2011), classical MRSA has been detected in bovine mastitis on the continent of Europe (Vanderhaeghen *et al*. 2010) but the role of the cattle as a source of human infection has not been well defined.

There are several possible mechanisms of (macrolide) resistance, the most important of which is the production of enzymes that alter the ribosomal binding site by methylation, and possession of an efflux pump. Genes for these enzymes may be on plasmids or transposons and may be readily transferable.

Figure 9: Susceptibility of *Staphylococcus aureus* mastitis isolates in cattle 2011-2013



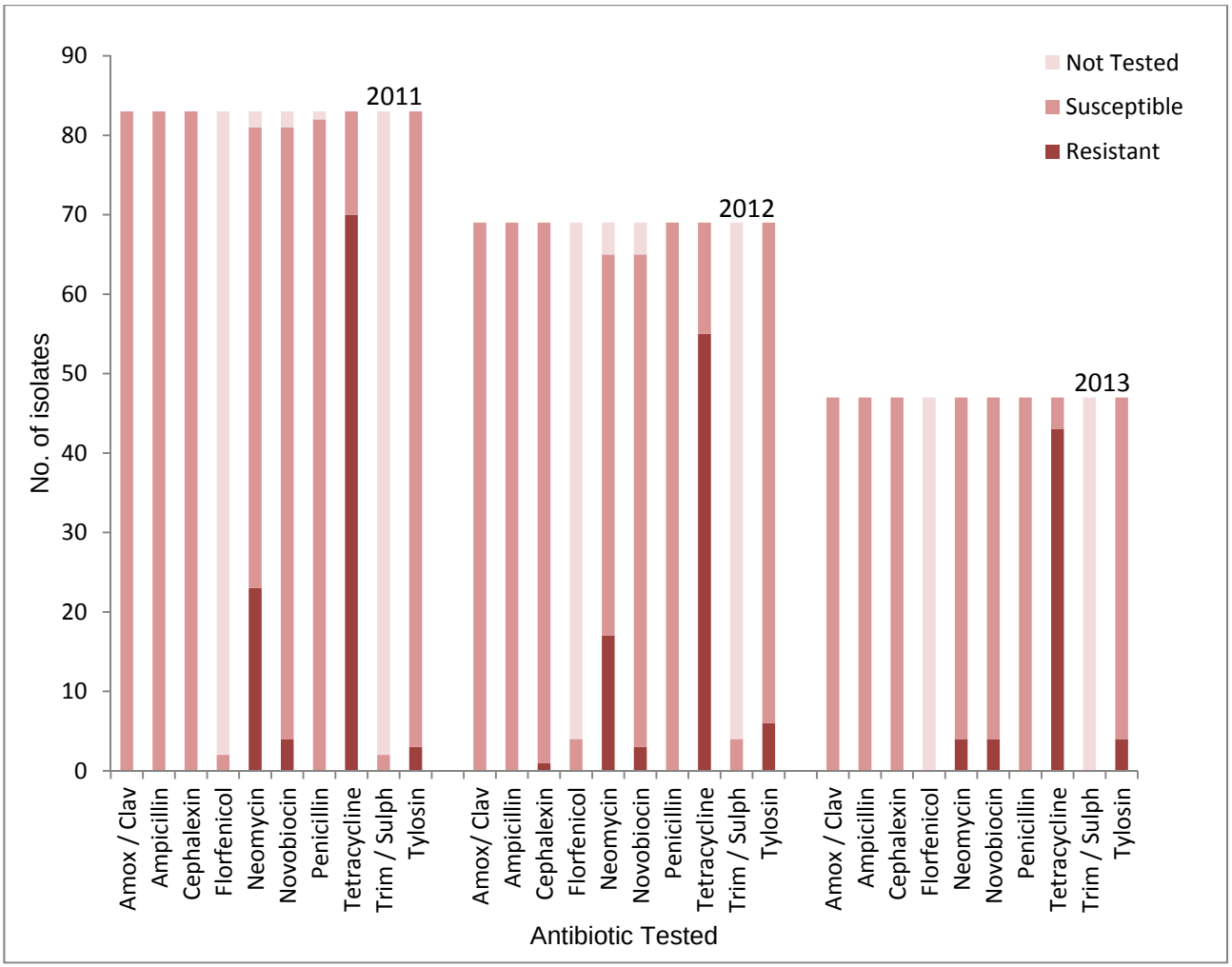
Streptococcus dysgalactiae

199 isolates were identified over the three year period; multiple resistance was not seen in any of the isolates (**Figure 10**). As could be expected in cattle greatest resistance was seen to tetracycline, which increased over the three years to 91% in 2013. Resistance to neomycin declined from 28% in 2011 to 9% in 2013. Resistance was seen to novobiocin and tylosin every year, in up to 9% of isolates.

Streptococcus dysgalactiae is a Lancefield Group C streptococcus and a commensal of the mucous membranes of cattle; it is a cause of mastitis and occasionally other diseases in cattle. It is not considered a zoonosis and Group C streptococci that can cause disease in humans constitute a separate population. There are several mechanisms of tetracycline resistance but one of the commonest is through an efflux pump mechanism. The gene encoding this protein may be located on a plasmid and therefore can be readily transferred between bacteria.

Macrolide resistance has been reported in *S. dysgalactiae* isolates from bovine mastitis from other parts of the world.

Figure 10: Susceptibility of *Streptococcus dysgalactiae* mastitis isolates in cattle 2011-2013



Trueperella pyogenes

70 isolates were identified over the three year period, multiple resistance was not detected (**Annex 5**). Resistance to tetracycline was the most commonly detected resistance, in up to 55% of isolates. Up to 38% of isolates were resistant to neomycin. Resistance to novobiocin and tylosin was detected in 2011 and 2012, but not in 2013.

Streptococcus agalactiae

Two isolates were identified over the three year period (**Annex 5**). One isolate was resistant to neomycin, no other resistance was noted.

Streptococcus agalactiae is a Lancefield Group B streptococcus considered to be an obligate inhabitant of the mammary gland of cows. It is not regarded as zoonotic and human Group B streptococci probably constitute a separate population.

Penicillin resistance has been reported in the literature in some types of streptococci such as *Streptococcus pneumoniae*, an important human pathogen. It has also been reported in veterinary isolates of *S. agalactiae* from some other parts of the world. Development of resistance in commensal streptococci, such as *Streptococcus mitis*, via mutation of the genes encoding penicillin binding proteins and subsequent recombination with the homologous genes in *S. pneumoniae* has been reported, reinforcing the role that the commensal flora may play as a reservoir of resistance genes. No resistance to ampicillin or amoxicillin/clavulanic acid was detected in *S. agalactiae* in 2011–2013.

Streptococci are in general naturally resistant to aminoglycosides due to lack of the active transport mechanism required for these drugs to be taken up into the bacterial cell.

Staphylococcus xylosus

One isolate was identified in 2011, no resistance was detected.

Respiratory Pathogens

Pasteurella multocida

Pasteurella multocida is a relatively uncommon cause of respiratory or systemic disease in cattle in the UK (the incidence of disease caused by this bacterium is much greater in North America and certain other parts of the world). Toxigenic strains are responsible for the development of atrophic rhinitis in pigs; strains of the organism can also affect poultry (fowl cholera). It is a rare pathogen of sheep in the UK. There is probably carriage in the upper respiratory tract of some animals and bovine strains are likely to be distinct from those infecting other species.

Cattle – 167 isolates were identified over the three year period, multiple resistance occurred in 3% of isolates in 2013 (**Figure 11**). Isolates in 2011 were susceptible to all antibiotics apart from tetracycline, to which 51% of isolates were resistant. In 2013 resistance was also seen to ampicillin (8%) and to cefpodoxime (3% not confirmed by follow up testing).

Sheep – 19 isolates were identified over the three year period, multiple resistance was not detected, (**Annex 5**), all isolates were susceptible apart from three which were resistant to tetracycline.

Pigs – 142 isolates were identified over the three year period, multiple resistance was seen in 2% in 2011, 3% in 2012 and 5% in 2013 (**Figure 12**). Tetracycline was the antibiotic against which highest levels of resistance were observed, (68-87%). Only 3-4% of isolates were resistant to doxycycline. This may reflect the resistance mechanism involved, as some genes confer resistance to tetracycline but not doxycycline, but this difference may also relate to breakpoint considerations. Resistance was observed to ampicillin in 2012 and in 2013 but was not seen in 2011. Resistance was also observed to apramycin, neomycin, streptomycin, trimethoprim/sulphonamide and tylosin. All of the isolates tested were susceptible to amoxicillin/clavulanic acid, cefpodoxime, enrofloxacin and florfenicol.

Figure 11: Susceptibility of *Pasteurella multocida* isolates in cattle 2011-2013

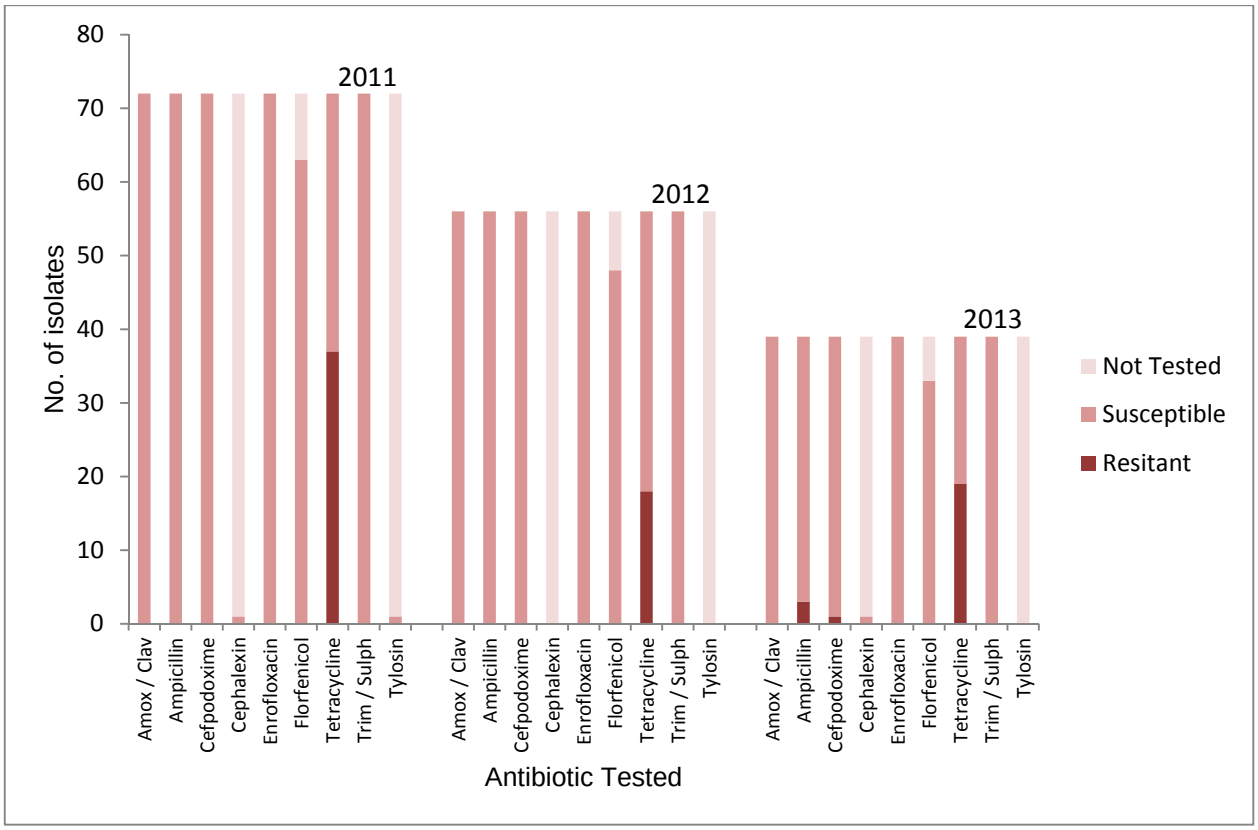
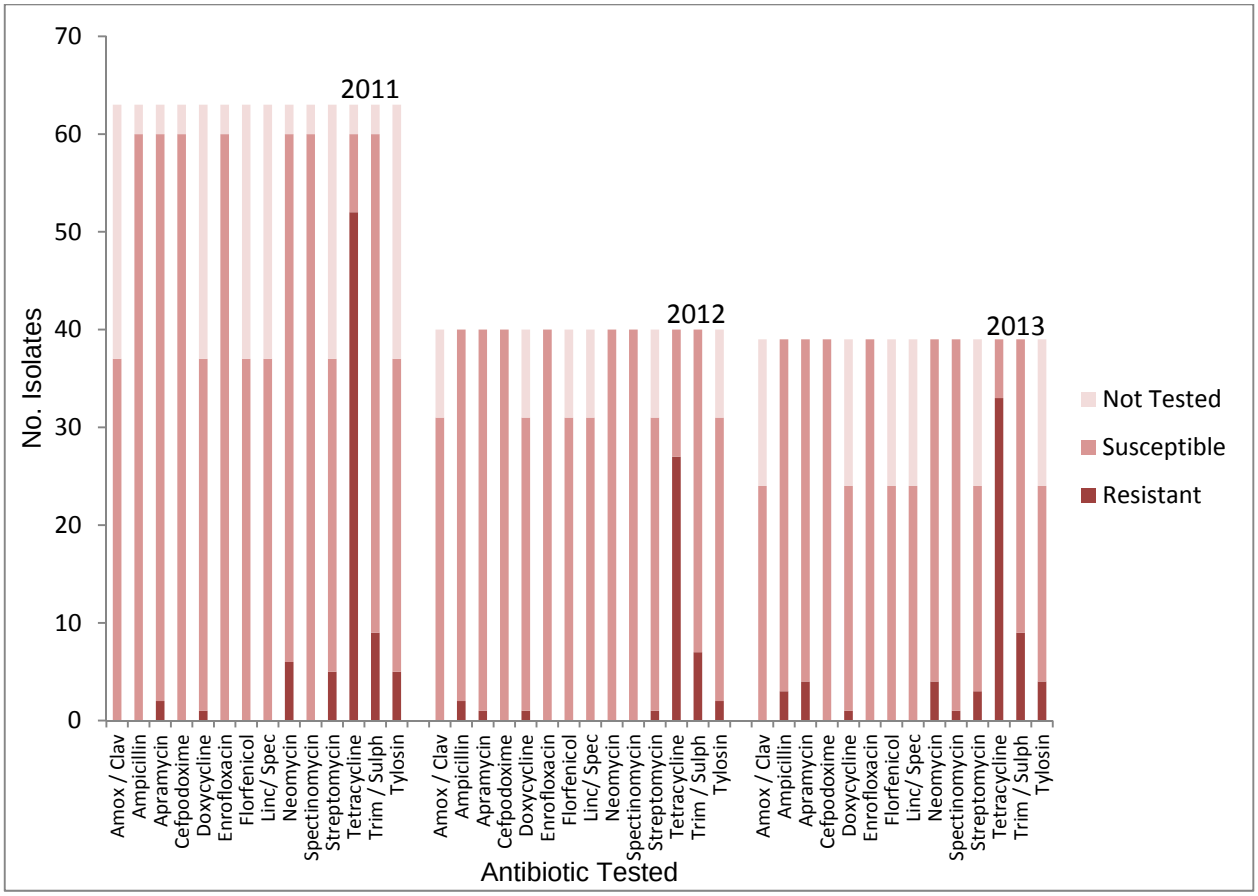


Figure 12: Susceptibility of *Pasteurella multocida* in pigs 2011-2013



Mannheimia (Pasteurella) haemolytica

Mannheimia (Pasteurella) haemolytica is a common cause of respiratory disease in both cattle and sheep in the UK although different serotypes predominantly affect each species. There is carriage in the upper respiratory tract in healthy animals. Ovine *Mannheimia* strains can also cause mastitis. *M. haemolytica* has also been more rarely recorded as causing mastitis in cattle.

Cattle – 92 isolates were identified over the three year period, 1% of isolates in 2011 were resistant to cefpodoxime and 4% were resistant to tetracycline.

Sheep – 116 isolates were identified over the three year period, no resistance was detected.

Bibersternia (Pasteruella) trehalosi

Sheep – 81 isolates were identified over the three year period, multiple resistance was not detected (**Annex 5**) Four isolates were resistant to tetracycline. No other resistance was detected.

Histophilus somni (Haemophilus somnus)

Histophilus somni (formerly known as *Haemophilus somnus*) is a cause of pneumonia in calves.

Cattle – 77 isolates were identified over the three year period, multiple resistance was detected in 4% of isolates in 2012, but was not detected in 2011 or 2013 (**Annex 5**). In 2011 1% was resistant to trimethoprim/sulphonamide and in 2012 1% was resistant to amoxicillin/clavulanic acid, ampicillin, cefpodoxime and tetracycline. No resistance was observed in 2013.

Actinobacillus pleuropneumoniae

Actinobacillus pleuropneumoniae is a cause of pneumonia in pigs. Levels of resistance to spectinomycin and other aminoglycosides detected in the disc diffusion test may reflect the rather high minimal inhibitory concentrations that have been described for *A. pleuropneumoniae* in the scientific literature for some aminoglycoside compounds (Leman *et al*. 1986).

Pigs – 62 isolates were identified over the three year period, multiple resistance was detected in 9% of isolates in 2011 and 50% of isolates in 2012, but was not detected in 2013 (**Annex 5**). Resistance to apramycin, ampicillin, neomycin, spectinomycin, streptomycin, tetracycline, doxycycline (one isolate) trimethoprim/sulphonamide and tylosin was detected. All isolates were susceptible to amoxicillin/clavulanic acid, cefpodoxime, enrofloxacin and florfenicol.

Trueperella pyogenes (Arcanobacterium)

Cattle – 71 isolates were identified over the three year period, multiple resistance was not detected (**Annex 5**). The greatest level of resistance was seen against tetracycline, (up to 72%). Isolates were also resistant to trimethoprim/sulphonamide (up to 50%) and tylosin (up to 11%). One isolate in 2012 was resistant to florfenicol.

Sheep – 31 isolates were identified over the three year period, multiple resistance was not detected (**Annex 5**). Resistance was observed against tetracycline (25%) and trimethoprim/sulphonamide (38%), and one isolate was resistant to tylosin in 2011.

Pigs – 11 isolates were identified over the three year period, multiple resistance was not identified (**Annex 5**). Resistance was observed in a small number of isolates to lincomycin, tetracycline, trimethoprim/sulphonamide and tylosin.

Other (miscellaneous) veterinary pathogens

Corynebacterium pseudotuberculosis

Corynebacterium pseudotuberculosis is the cause of caseous lymphadenitis in sheep; it has been reported as a zoonosis though it rarely infects man. However, Corynebacteria may be emerging zoonoses, particularly in humans with immunosuppressive disease, such as HIV infection.

Irrespective of in vitro susceptibility, treatment of clinical cases of this infection in sheep is often difficult because of the difficulties in delivering sufficient antibiotic to the typical “onion-ring” abscesses that occur.

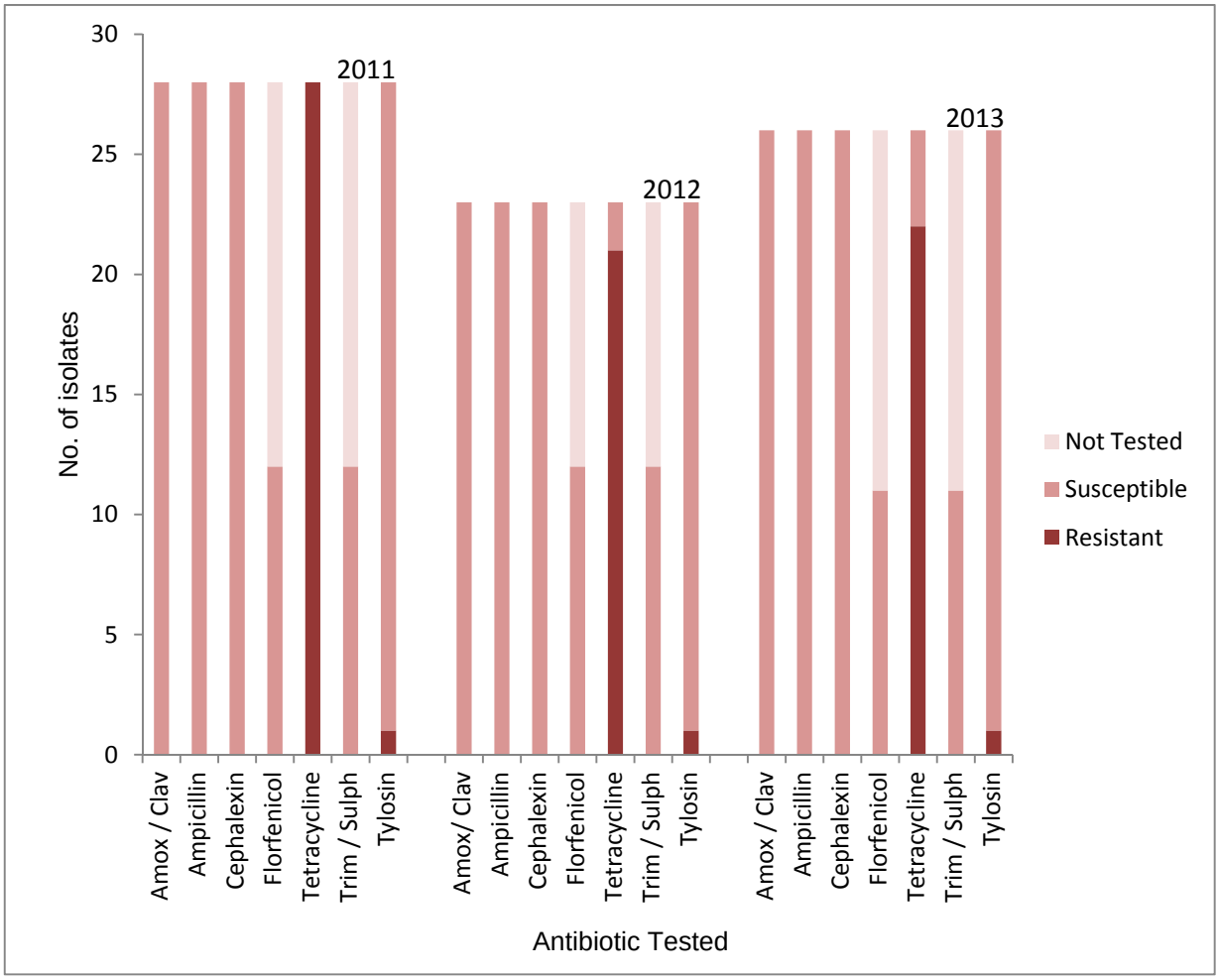
Sheep – 19 isolates were identified over the three year period, multi-resistance was not detected. No resistance was observed in 2013, although in 2011-2012 two isolates were resistant to tetracycline and one isolate was resistant to trimethoprim/sulphonamide.

Streptococcus dysgalactiae

Streptococcus dysgalactiae is the major cause of infectious arthritis in young lambs and is probably carried on the mucous membranes of a small proportion of sheep. The degree of relatedness between ovine and bovine strains of *S. dysgalactiae* is not known.

Sheep – 77 isolates were identified over the three year period, multiple resistance was not detected, and in 2011 all of the isolates tested were resistant to tetracycline, this figure declined to 85% in 2013. Resistance was also seen to tylosin in 4% (one isolate) each year. The isolates were susceptible to all of the other antibiotics tested.

Figure 13: Susceptibility of *Streptococcus dysgalactiae* isolates from sheep 2011-2013



Staphylococcus aureus

Staphylococcus aureus causes a number of infections in poultry and game birds, including septicaemia, yolk sac infection, arthritis and osteomyelitis.

Pigs – Two isolates were received in 2013, one demonstrated resistance to ampicillin. Neither was resistant to cefoxitin, the antibiotic used to screen for methicillin resistance.

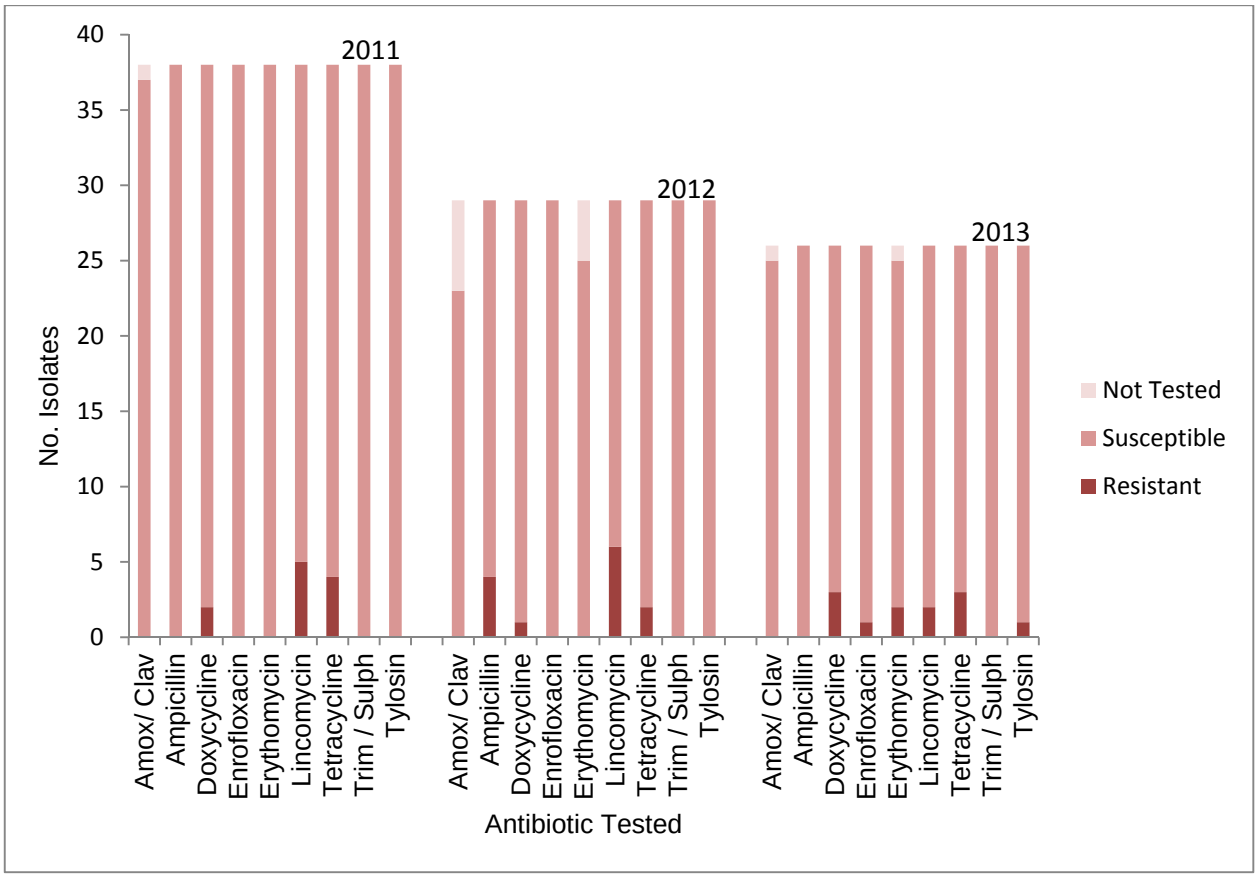
Chickens – 93 isolates were identified over the three year period, multiple resistance was not detected (**Figure 14**). In 2011 and 2012 the greatest resistance observed was to lincomycin (13% and 21% respectively). In 2013 highest levels of resistance were seen against tetracycline and doxycycline, with 12% of isolates demonstrating resistance to both, 8% of isolates were resistant to erythromycin and lincomycin in 2013, and 4% were resistant to enrofloxacin and tylosin. No resistance was seen to amoxicillin/clavulanic acid or trimethoprim/sulphonamide.

Turkeys – Two isolates were identified over the three year period, resistance was detected in one isolate (see text box).

The *S. aureus* isolate recovered in 2013 from a turkey on a farm in East Anglia was resistant to ampicillin, amoxicillin/clavulanic acid and cefoxitin and proved to be livestock-associated methicillin-resistant *S. aureus* (LA-MRSA) multi-locus sequence type 398 (**Table 25**). This was the first report of MRSA made directly from a food-producing animal in the UK. The organism was recovered as an incidental finding in low growth from the lung of a turkey which had died of Marek's disease. A subsequent farm visit confirmed the presence of MRSA ST398 on the farm in turkeys and to a lesser extent in broilers. LA-MRSA is considered to be of low virulence in humans.

Other avians – Six isolates were identified over the three year period, multiple resistance was detected in three isolates (**Annex 5**). Resistance was observed against doxycycline, erythromycin, lincomycin, tetracycline and tylosin.

Figure 14: Susceptibility of *Staphylococcus aureus* in chickens 2011-2013



Staphylococcus xylosus

Staphylococcus xylosus is a coagulase-negative *Staphylococcus* which has been reported to cause dermatitis in sheep and mastitis in cattle.

Chickens – Seven isolates were identified over the three year period, multi-resistance was detected in four of the isolates (**Annex 5**). Resistance to doxycycline, erythromycin, lincomycin, tetracycline and tylosin was detected in a small number of isolates.

Turkey – One isolate was detected in 2011 and demonstrated resistance to doxycycline, lincomycin, and tetracycline.

Brachyspira hyodysenteriae* and *Brachyspira pilosicoli

Brachyspira hyodysenteriae and *Brachyspira pilosicoli* cause colitis and dysentery in pigs; in addition *B. pilosicoli* is recognised as an occasional zoonosis, causing enteritis in man. *B. hyodysenteriae* is the causative organism of swine dysentery, an enteric disease of pigs, resulting in serious ill-thrift in its chronic form.

There is a limited range of authorised antibiotics available for the treatment of swine dysentery and since resistance arises through mutation, reliance on ongoing medication without addressing other aspects of disease control, such as hygiene and herd husbandry (for example all-in; all-out management or periodic depopulation) carries the attendant risk that mutational resistance may arise.

Tiamulin is an important antibiotic used for the treatment of swine dysentery. Tiamulin-resistant isolates may also show resistance to some or all of the other antibiotics currently used for treatment. When resistance occurs to all of the available therapeutic antibiotics then important animal welfare considerations arise, since affected pigs can respond poorly to treatment and fail to thrive. In such instances, the only practical option may eventually be to depopulate herds, with economic implications for the farmer. *B. pilosicoli* infection in pigs is generally a milder clinical disease and resistance appears to be less of an issue in relation to treatment.

Because of the importance of this disease and the significance of resistance to tiamulin, all isolates of *B. hyodysenteriae* are tested for tiamulin susceptibility each year. For the isolates reported here, an agar plate dilution method was used to determine the tiamulin MIC. Isolates were tested in duplicate on a single occasion, including appropriate controls of known MIC. A breakpoint of resistance > 4 mg/l tiamulin was used (Rønne and Szancer 1990); this has also recently been quoted in a Dutch study of swine dysentery in pigs (Duinhof *et al*. 2008).

Pigs – 29 isolates of *Brachyspira hyodysenteriae* were received over the three year period. An agar plate dilution was used to determine the tiamulin minimum inhibitory concentration (MIC). The breakpoint of resistance used was >4mg/l tiamulin. In 2011 none of the 12 isolates recovered were resistant to tiamulin; in 2012 three of the nine isolates were on or above the 4mg/l cut off; and in 2013 four of the eight isolates were on or above the cut off. These figures include some “repeat isolates”, i.e. obtained from the same premises.

Zoonotic Bacteria

Erysipelothrix rhusiopathiae

(**Annex 5**)

Erysipelothrix rhusiopathiae is widely distributed in nature and can be a commensal or pathogen of a very wide range of vertebrate and invertebrate species. The main reservoir amongst the domestic species is probably pigs, though infection of both birds and rodents are said to be common.

Pigs – 21 isolates were identified over the three year period, no multi-resistance was identified. One isolate was resistant to tetracycline in 2011 and 2012. In 2013, four of the 11 isolates were resistance to tetracycline. 14 isolates were resistant to trimethoprim/sulphonamide from 2011-2013. All of the isolates were susceptible to ampicillin, enrofloxacin, lincomycin and tylosin.

Sheep – One isolate was submitted in 2012, which was resistant to trimethoprim/sulphonamide but susceptible to ampicillin, tetracycline and tylosin.

Avian – 23 isolates were identified over the three year period and came from three chickens, one pheasant and seven turkeys in 2011; one chicken and three turkeys in 2012; and five chickens and three turkeys in 2013. Multi-resistance was seen in one isolate in 2013. Trimethoprim/sulphonamide resistance was detected in 2013 in 3/5 isolates from chickens and 1/3 isolates from turkeys; whilst the three turkey isolates were susceptible to tetracyclines, 4/5 isolates from chickens were resistant. A single isolate from chickens was resistant to enrofloxacin. All isolates, irrespective of the species from which they were isolated, were susceptible to penicillin/ampicillin (**Table 19**).

Listeria

(**Annex 5**)

Listeria is widely distributed in the environment and can be isolated from soil, decaying vegetation and poorly fermented silage. Asymptomatic faecal carriage occurs in man and in many species of animal. Two main disease syndromes exist: neural infection and infection of the foetus *in utero,* resulting in abortion/neonatal septicaemia. Humans may be infected, usually through consumption of contaminated foods such as soft cheese, poultry meat or milk.

Cattle – (*Listeria monocytogenes*) 13 isolates were identified over the three year period. Eight isolates were resistant to cephalexin from 2011-2012; this reflects the intrinsic resistance of *Listeria* to this compound. All isolates were susceptible in 2013. No other resistance was detected.

Sheep – (*Listeria monocytogenes*) 42 isolates were identified over the three year period, no multi-resistance was identified. In 2011 and 2012, 31 out of 32 isolates were resistant to cephalexin, in 2013 the level of resistance observed reduced to 3/10. One isolate was resistant to tetracycline in 2012 but all other isolates were susceptible to the antibiotics tested.

Sheep – (*Listeria ivanovii*) six isolates were identified over the three year period; two isolates in 2011 were resistant to cephalexin, no other resistance was observed.

Streptococcus suis and Streptococcus equi zooepidemicus

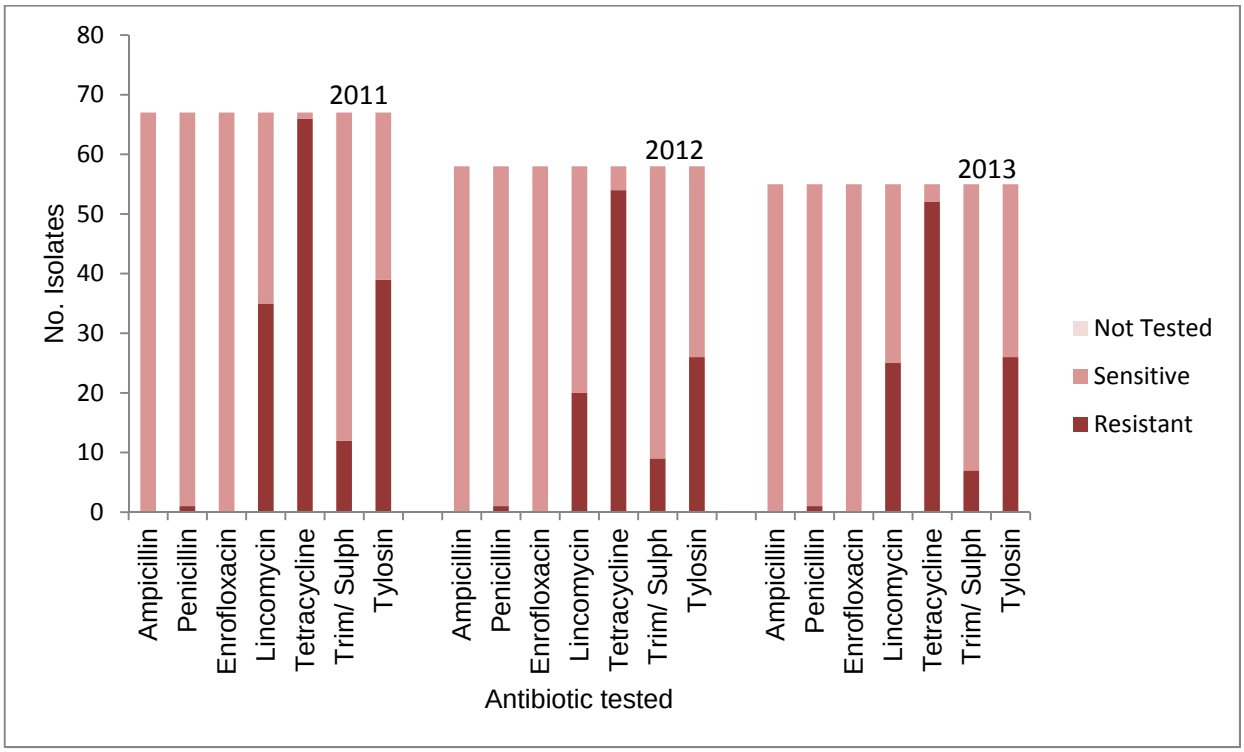
Streptococcus suis is a pathogen of pigs that can cause pneumonia, meningitis and arthritis. It can also rarely infect man. *Streptococcus equi zooepidemicus* is a pathogen and occasionally a commensal of equines and less commonly other species. Humans may be infected by consuming infected milk, although the organism is rare in cattle.

Pigs – (*Streptococcus suis*) 180 isolates were identified over the three year period, multi-resistance was seen in 10% of isolates in 2011, 2% in 2012 and 4% in 2013 (**Figure 15**). The highest level of resistance observed was to tetracycline (93-95%), 34-52% of isolates were resistant to lincomycin, 45-58% were resistant to tylosin, 13-18% were resistant to trimethoprim/sulphonamide and up to 2% were resistant to penicillin. All of the isolates were susceptible to ampicillin and enrofloxacin.

Penicillin MIC determinations have been performed on 100 archived recent *S. suis* isolates and two isolates from 2009/2010 from cases of clinical streptococcal disease in pigs. Isolates were found to have penicillin MICs of >0.25 mg/l, the BSAC human clinical breakpoint for resistance in beta-haemolytic streptococci. Considering that the majority of *S. suis* isolates tested had penicillin MICs of 0.006 to 0.064 mg/l, this finding is considered to confirm reduced penicillin susceptibility.

Horses – (*Streptococcus equi zooepidemicus)* One isolate was identified over the three year period and was resistant to tetracycline only.

Figure 15: Susceptibility of *Streptococcus suis* in pigs 2011-2013



Klebsiella pneumoniae

(**Annex 5**)

Avian – Three isolates were identified over the three year period, multi-resistance was present in two isolates in 2012, one from a swift and one from a pheasant. In 2013 there was one isolate from an unidentified avian which was not multi-resistant. Resistance was detected to ampicillin in all isolates, spectinomycin in two isolates, tetracycline in one isolate and trimethoprim/sulphonamide in two isolates.

Yersinia pseudotuberculosis

(**Annex 5**)

Sheep – Three isolates were identified over the three year period, no resistance was identified.

Escherichia coli

E. coli are an important group of bacteria as they are ubiquitous in farm animal species and are potentially pathogenic zoonosis. They can also occur as commensal organisms and have the capacity to be a reservoir of transferable resistance determinants and in structured European surveillance programs, only commensal organisms are sampled and are designated as indicator organisms.

This section includes all isolates of *Escherichia coli* and coliform bacteria presumptively identified as *E. coli*, which were identified through scanning surveillance, apart from isolates recovered from milk which are included in the section on mastitis organisms. The majority of isolates reported in this section were recovered from faeces or intestinal contents. For some species the age of the animal at the time of sampling can have a large impact on the percentage of resistant isolates detected, as the prevalence in neonates is greater than in adults. If the data for all ages are combined, then apparent trends may be misleading as the younger animals skew the data. For that reason in this section the data for cattle, sheep and pigs are divided by age into neonatal, pre/post-weaning and adult. When viewing these data the number of isolates in each group should be considered as well as the percentage of resistant isolates, especially when comparing resistance in different age groups, as percentages may appear similar when in fact the total numbers of resistant isolates are quite different. Coliforms presumptively identified as *E. coli* referred to in this section will include some strains which are pathogenic for animals, as well as commensal strains.

Resistance to third generation cephalosporins (cefotaxime, ceftazidime, cefpodoxime) detected in *E. coli*/coliforms in animals will include resistance mediated by both ESBL and AmpC resistance mechanisms.

Cattle – 2571 isolates were identified over the three year period.

Neonates – 832 samples were received over the three year period from neonates, the proportion of multiply resistant isolates increased over the period 2011-2013; 66%, 70% and 75% respectively. Highest resistance was seen to ampicillin (80%) in 2011; this level of resistance remained constant over the following two years. Tetracycline resistance was also common (78% each year). In 2011 70% of isolates were resistant to streptomycin; this decreased to 59% in 2012 then increased to 62% in 2013. Over the three year period resistance was seen to chloramphenicol (55-59%), amoxicillin/clavulanic acid (47-57%), spectinomycin (46-53%), trimethoprim/sulphonamide (44-46%), neomycin (37-41%), florfenicol (31-35%), cefotaxime (13-15%),

enrofloxacin (10-12%) and ceftazidime (7-8%). There was no resistance to amikacin in 2011 but 1% of isolates were resistant in 2012 and 2013.

Pre-weaning – 250 isolates were identified over the three year period from pre weaning aged calves, the proportion of multi-resistant isolates increased over the period 2011-2013; 61%, 66% and 70% respectively. As observed in isolates from neonates there was a high level of resistance to ampicillin (76-80%). However, the highest resistance was against tetracycline (up to 85%). Over 2011-2013, between 62-70% of isolates were resistant to streptomycin, 47-65% were resistant to chloramphenicol, 49-53% were resistant to trimethoprim/sulphonamide, 43-50% were resistant to florfenicol, 40-49% were resistant to neomycin, 36-42% were resistant to spectinomycin, 39-42% were resistant to amoxicillin/clavulanic acid, 20-24% were resistant to cefotaxime, 6-11% were resistant to ceftazidime. 4% of isolates were resistant to amikacin in 2012, but no resistance was seen to this antimicrobial in 2011 or 2013.

Adult – 52 isolates were identified from adult cattle over the three year period. Due to the low numbers of isolates the percentage of resistant isolates are not presented. As with the other age brackets highest resistance was seen to ampicillin and tetracycline, with up to seven isolates being reported as resistant each year. Resistance was seen to all of the antibiotics apart from amikacin.

Figure 16: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult cattle 2011

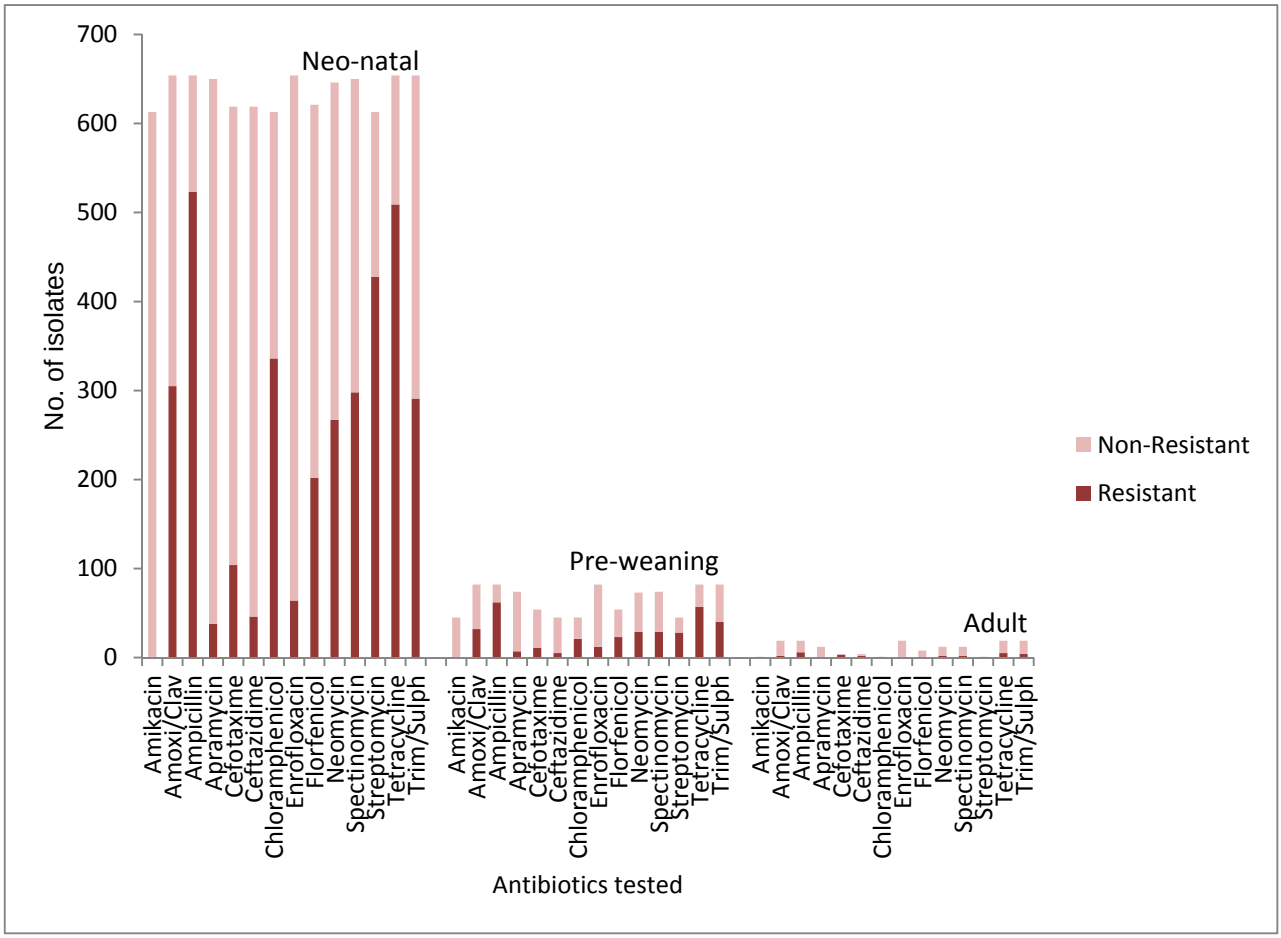


Figure 17: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult cattle in 2012

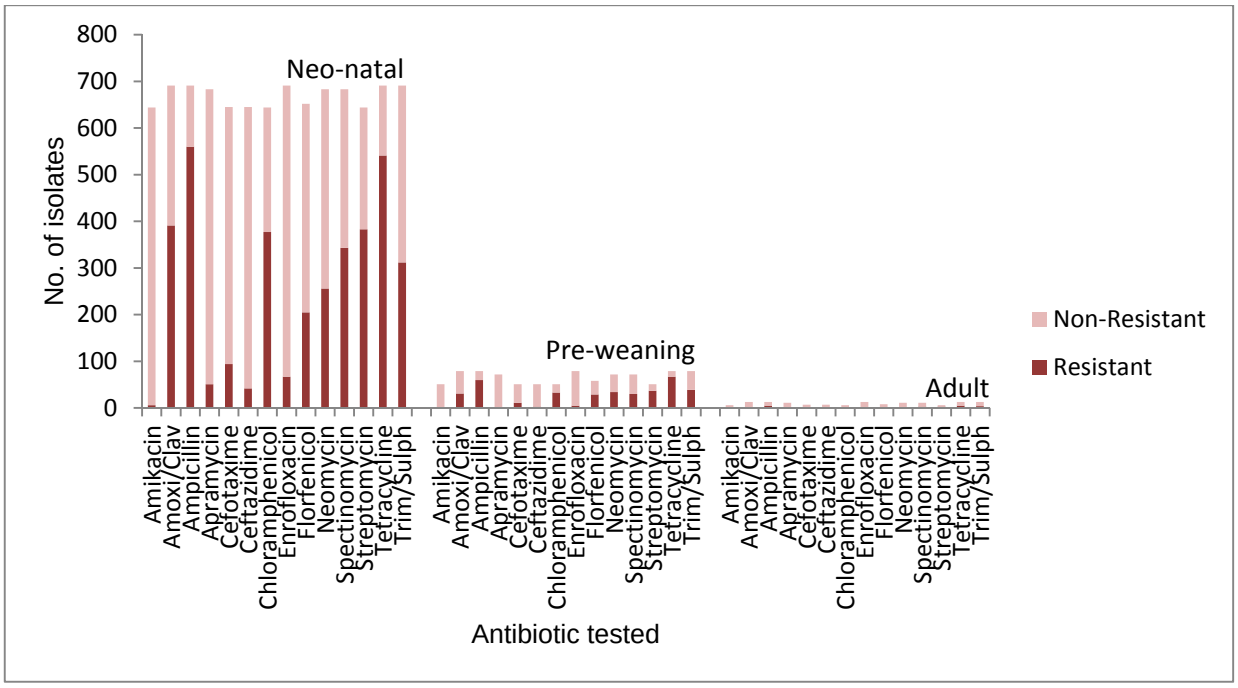
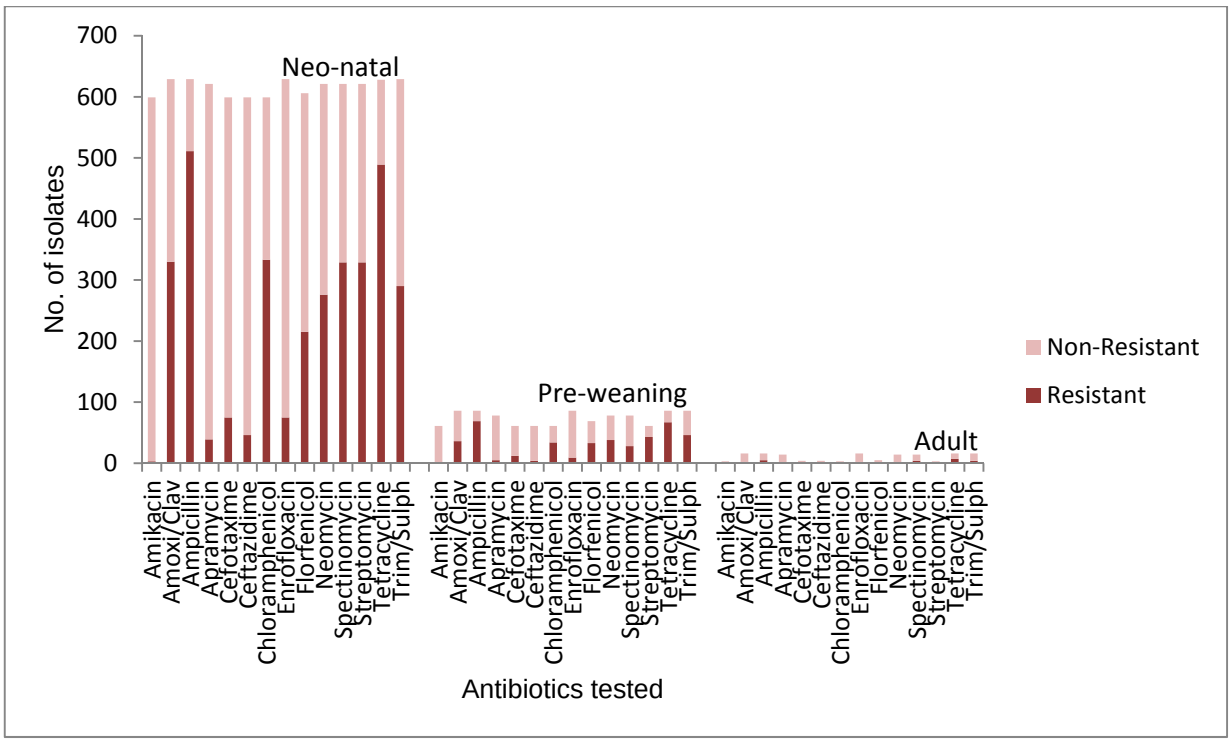


Figure 18: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult cattle in 2013



Sheep – 473 isolates were identified over the three year period.

Neonatal – 368 isolates were identified from neonatal sheep over the three year period. The proportion of multi-resistant isolates increased over the period 2011-2013; 31%, 38% and 54% respectively. Highest resistance was seen to tetracycline, increasing from 56% in 2011 to 75% in 2013. Resistance also increased over the three years to ampicillin (53%-62%), streptomycin (43-55%), spectinomycin (39-59%), trimethoprim sulphonamide (21-31%), florfenicol (4-17%), neomycin (11-19%) and enrofloxacin (0-3%). Resistance was

also seen to amoxicillin/clavulanic acid (18-28%), apramycin (1-2%), and ceftazidime (1-4%), although resistance to these antibiotics did not increase each year.

Pre-weaning – 56 isolates were identified from pre-weaning sheep over the three year period. In 2011 multi-resistance was seen in 18% of isolates, but was not observed in 2012 or 2013. The numbers of isolates tested against each antibiotic were low. No resistance was seen to apramycin, ceftazidime or enrofloxacin.

Adult – 50 isolates were identified from adult sheep over the three year period. Multiple resistance was observed. Highest resistance each year was seen to tetracycline (8-16%) and ampicillin (6-12%).

Figure 19: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult sheep in 2011

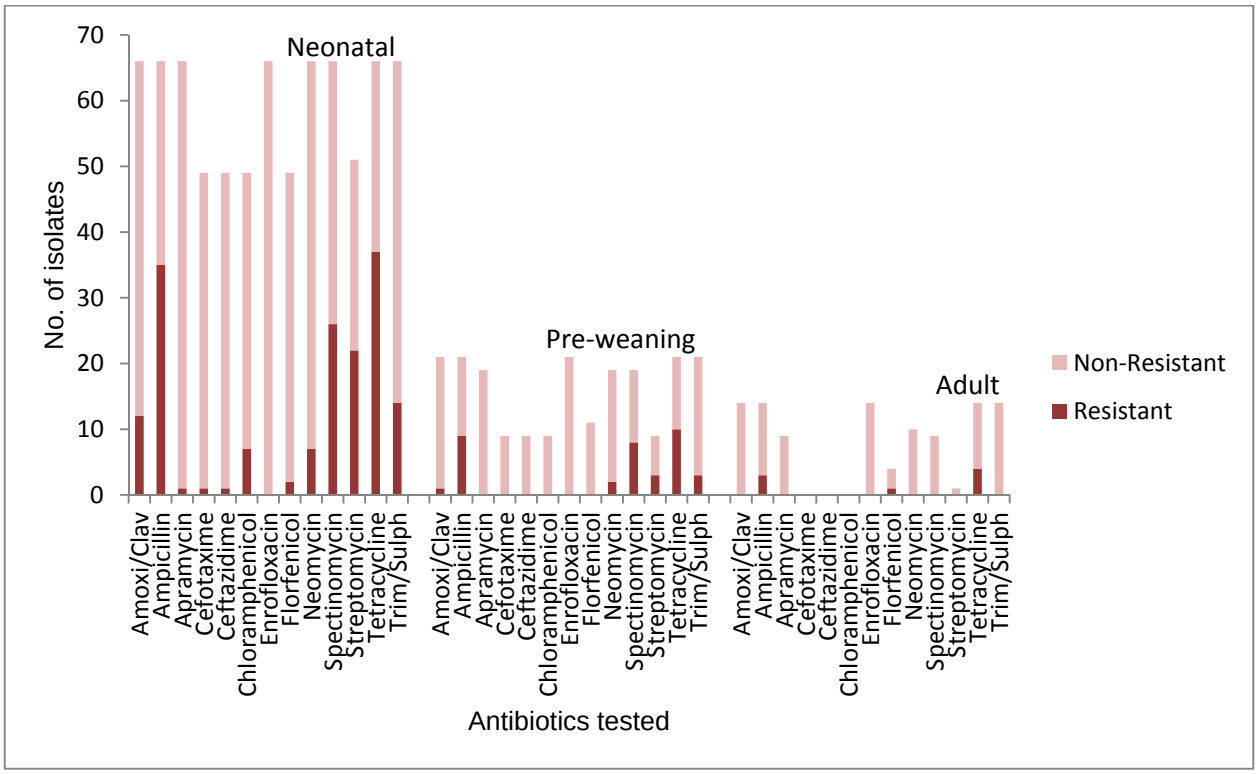


Figure 20: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult sheep in 2012

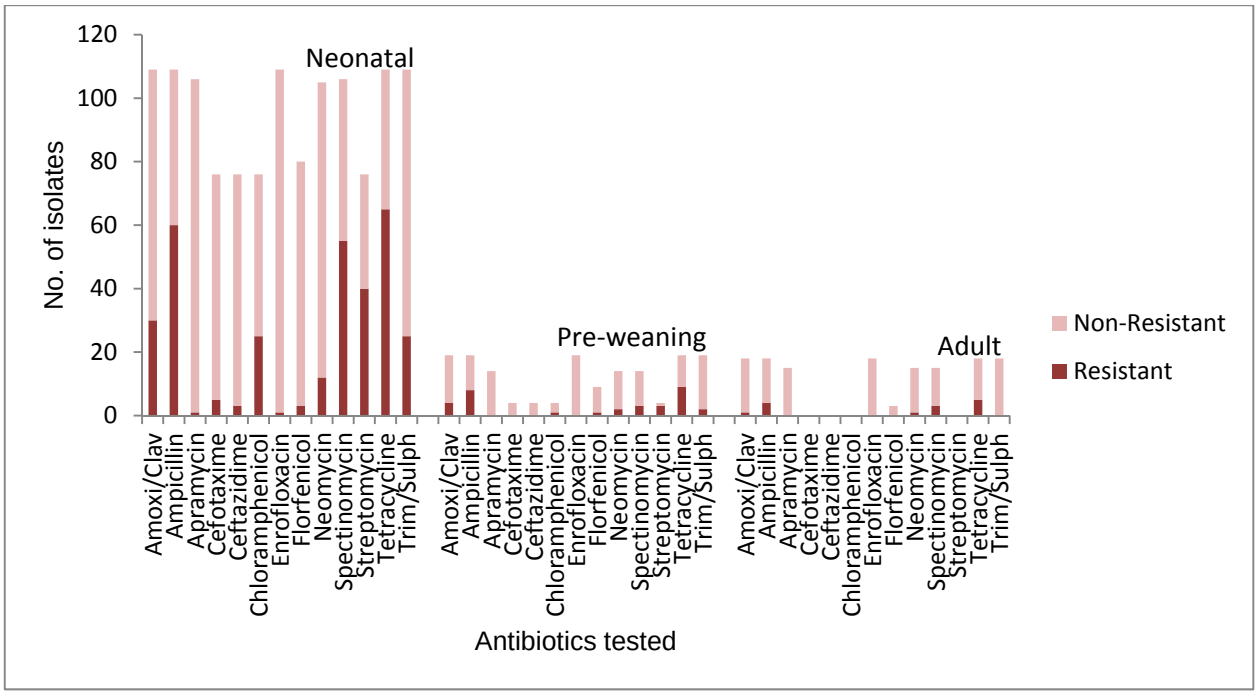
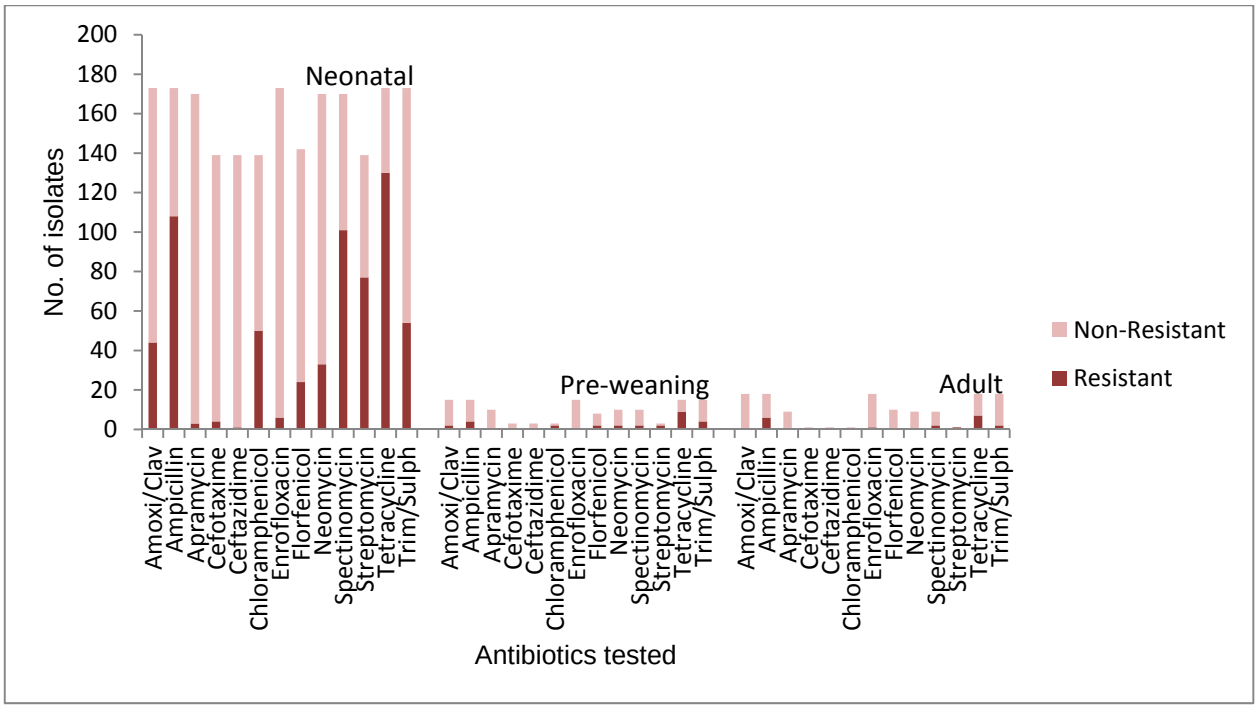


Figure 21: Susceptibility of *E. coli* isolates in neonatal, pre-weaning and adult sheep in 2013



Pigs – 291 isolates were identified over the three year period.

Neonatal – 112 isolates from neonatal piglets were identified over the three year period. The proportion of multi-resistant isolates varied over the period 2011-2013; 61%, 66% and 46% respectively. Overall the number of isolates recovered was low, and as not every isolate was tested against every antibiotic, caution should be taken when interpreting trends; it is advised to view graphs alongside the raw data in **Annex 5**. Highest resistance was seen to tetracycline (73%) = 49-69% of isolates were resistant to ampicillin, 50-58% of isolates were resistant to trimethoprim/sulphonamide and 24-43% of isolates were resistant to

spectinomycin. Resistance was seen to all antibiotics though in many cases fewer than 20 isolates were resistant.

Post-weaning – 157 isolates were identified over the three year period; the proportion of multi-resistant isolates increased over the period 2011-2013; 38%, 62% and 69% respectively. As with the isolates from neonates the highest levels of resistance were seen to tetracycline, trimethoprim/sulphonamide, ampicillin and spectinomycin. Unlike the pattern seen in isolates from neonates, a large number of isolates were also resistant to doxycycline, (up to 65%), and 26-38% of isolates were resistant to apramycin.

Adult – 22 isolates were identified over the three year period, as there were less than 20 isolates per year the proportion of resistance has not been calculated.

Figure 22: Susceptibility of *E. coli* isolates in neonatal, post-weaning and adult pigs in 2011

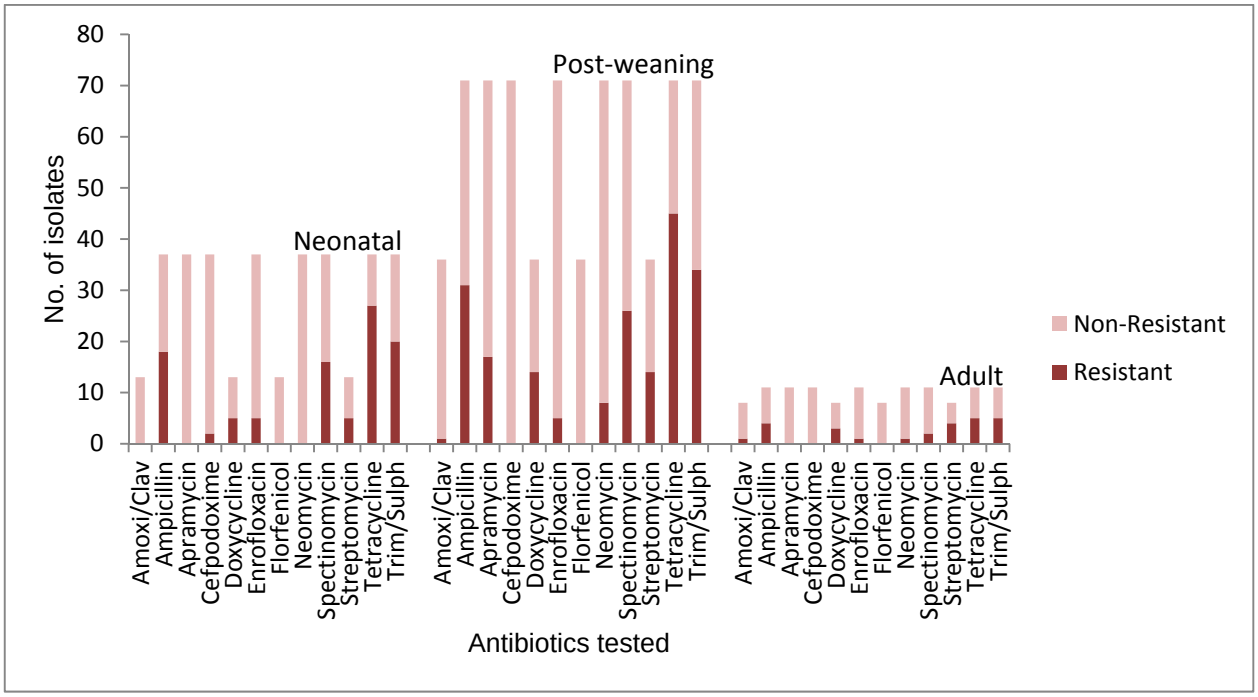


Figure 23: Susceptibility of *E. coli* isolates in neonatal, post-weaning and adult pigs in 2012

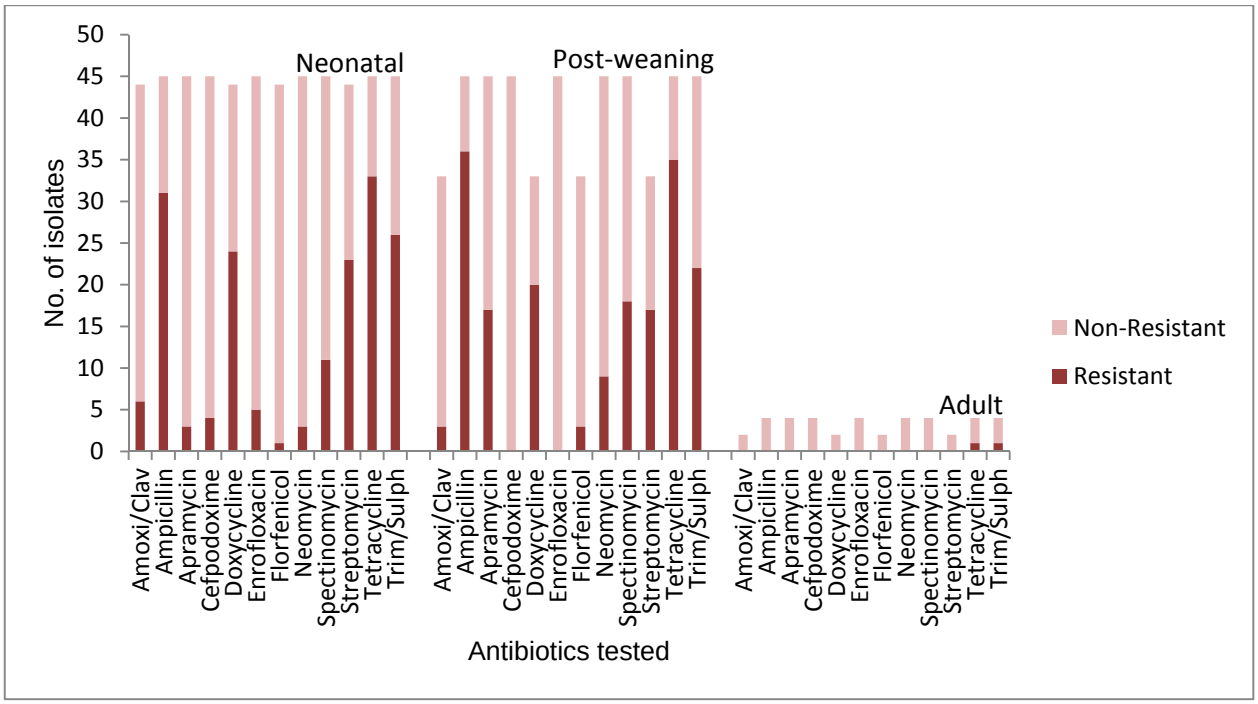
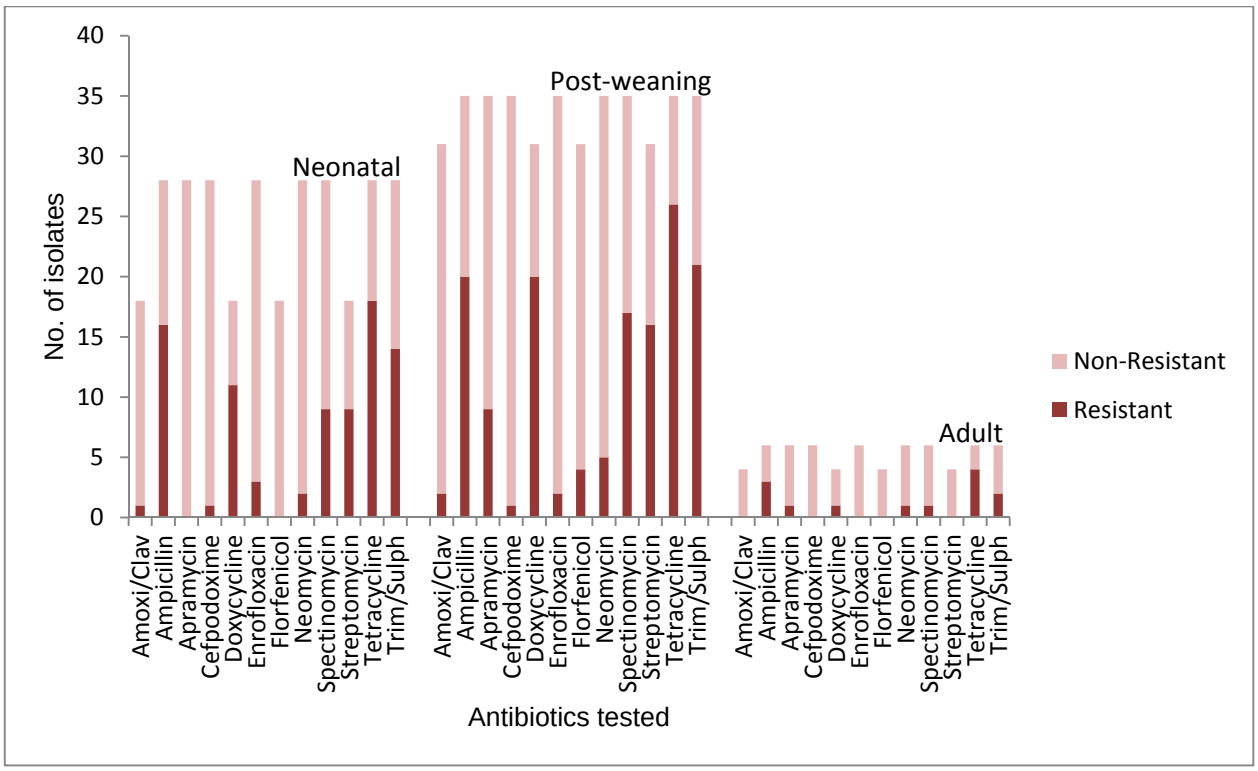


Figure 24: Susceptibility of *E. coli* isolates in neonatal, post-weaning and adult pigs in 2013



Chickens – 947 isolates were identified within the three year period; the proportion of multiply resistant isolates varied over the period 2011-2013; 21%, 29% and 15% respectively. Highest levels of resistance were seen to ampicillin (33-49%) and tetracycline (36-39%). Resistance to doxycycline was observed in 14-22% of isolates, 12-18% of isolates were resistant to trimethoprim/sulphonamide, and 5-22% were resistant to amoxicillin/clavulanic acid. Less than 10% of isolates were resistant to neomycin, enrofloxacin or apramycin.

Sensitivity to amikacin, cefotaxime, ceftazidime, florfenicol and streptomycin was not tested in most isolates.

Turkeys – 61 isolates were identified over the three year period, in 2011 41% of isolates were multi-resistant, in 2012 33% of isolates were multi-resistant, and in 2013 a total of six isolates were identified and no multi-resistance was observed. In 2011 88% of isolates were resistant to tetracycline, decreasing to 58% in 2012. In 2011 and 2012 resistance was observed to doxycycline (72-45%), ampicillin (38-55%), trimethoprim/sulphonamide (21-34%), spectinomycin (22-15%) and enrofloxacin (6-25%). One isolate was resistant to amoxicillin/clavulanic acid in 2011 and neomycin. No resistance was seen to cefpodoxime.

Salmonella spp.

Salmonella differs from the other bacteria in this report, as there is a National Control Programme[12] in place to reduce the prevalence of *Salmonella* in poultry. As a consequence the surveillance for this pathogen is enhanced (See Data Sources page 14). This section presents all of the *Salmonella* isolates that were tested for resistance in 2011-2013.

Due to the importance of *Salmonella* as a zoonotic pathogen it is considered useful to look at the serotype and even phage type of the isolate when investigating potential epidemiological links between animal and human cases. In this section an overview of all *Salmonella* isolates will be provided. Individual serotypes are then reported for 2011-2013.

It should be noted that most cases of non-typhoidal *Salmonella* infection in humans are non-invasive and limited to the gastro-intestinal tract and therefore do not require antibiotic treatment.

Salmonella isolates received for serological identification were tested for their *in vitro* sensitivity to 16 antibiotics (**Annex 5**). The choice of antibiotics, which is reviewed periodically, is designed to comprise a core set which has been used in veterinary practice for many years, as well as some of the more recently licensed antibiotics and some of limited or no usage in animals in Great Britain, but which are used in human medicine. All tests are performed using the British Society for Antimicrobial Chemotherapy (BSAC) disc diffusion technique (www.bsac.org.uk) on Oxoid "Isosensitest" agar and antimicrobial discs as listed in **Annex 6**. BSAC recommendations have also been adopted in relation to most breakpoints, where BSAC breakpoints are available. Where no BSAC breakpoints are available, then the historical veterinary breakpoint has been used as described in **Annex 6**. There were no changes made to the breakpoints or disc concentrations used for *Salmonella* testing over the period 2008-2011 apart from In 2012, the zone size breakpoint for the ceftazidime disc was reduced to resistant $\leq$ 26mm from 29mm in line with BSAC recommendations.

Resistance to third generation cephalosporins and fluoroquinolones is considered of most importance, as these antibiotics are particularly relevant for the treatment of human salmonellosis. Where resistance to these antibiotics is detected in a food producing animal, attempts are made to visit the farms, in order to explain the significance of the findings and provide appropriate advice on control.

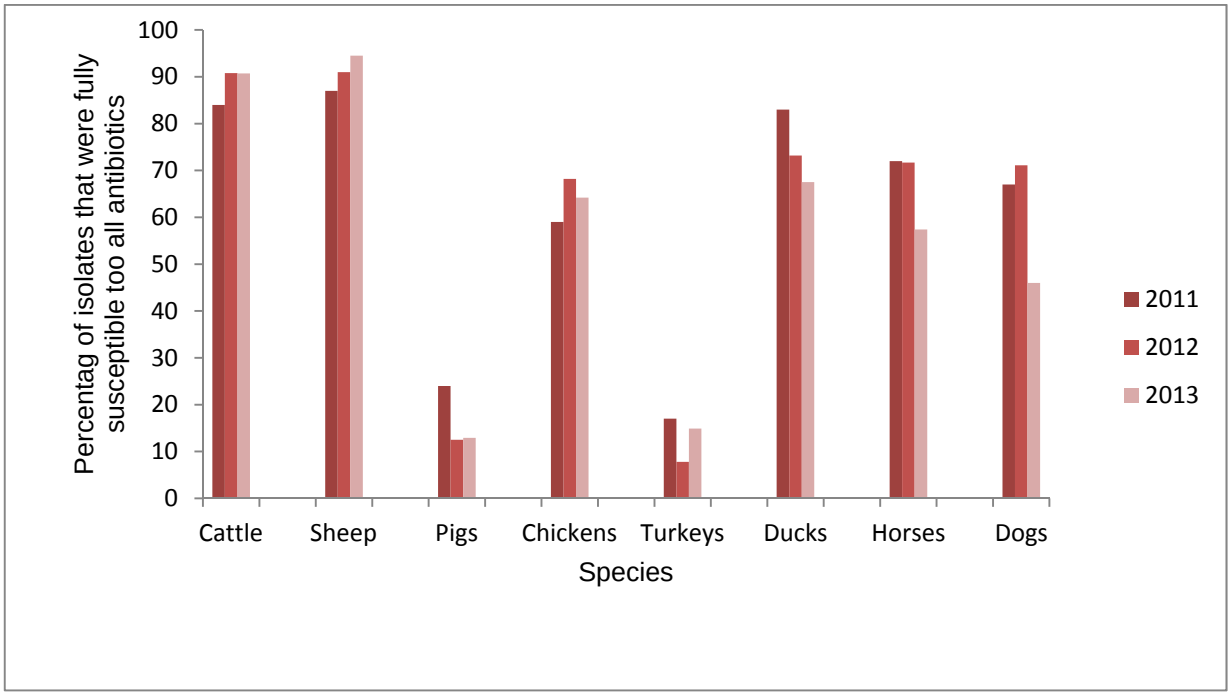
[12] http://archive.defra.gov.uk/foodfarm/farmanimal/diseases/atoz/zoonoses/documents/reports/ncp-salmonella.pdf

The number of cultures received from any one farm varies enormously, especially in the case of those received from poultry premises. Some poultry companies have a continuous monitoring programme in place and thus large numbers of *Salmonella* isolates may be received from a particular company. In that situation the numbers of isolates of a particular serotype and their antibiotic susceptibility may not reflect the prevalence in the animal population as a whole but rather the intensity of the monitoring programme on a farm or group of farms. Therefore, to indicate better the prevalence of resistance, only the first isolate of a given serotype or phage definitive type (DT) from each incident has usually been tested from each incident.

All *Salmonella*

All species – 8284 isolates were identified over the three year period; in 2011 59.4% of 2862 isolates were susceptible to all antibiotics, in 2012, 59.7% of 2436 isolates were fully susceptible and in 2013, 64.2% of 2886 isolates were fully susceptible. **Figure 25** shows the percentage of susceptible isolates recovered from each animal species. The resistance to individual antibiotics in isolates from each species is described below, and the relevant data tables can be seen in **Annex 5**.

Figure 25: Percentage of fully susceptible isolates in each species 2011-2013



Cattle – 1687 *Salmonella* isolates were identified over the three year period. In 2011 84% of isolates were fully susceptible to all antibiotics; this increased to 90.8% in 2012 and remained at that level in 2013. In 2011 highest levels of resistance were observed to streptomycin and tetracycline (12%); resistance to both antibiotics decreased to 6.2% in 2013. 5-10% of isolates were resistant to ampicillin and 5.4-10% of isolates were resistant to sulphonamides over the three year period. 3% of isolates were resistant to chloramphenicol in 2011 and this decreased to 1% in 2013. In 2011 resistance was observed at a level of 1% or less to nalidixic acid, ciprofloxacin, neomycin, apramycin, gentamicin and trimethoprim/sulphonamide. A reduction in resistance was seen over the next two years to all of these antibiotics apart from nalidixic acid, which increased to 1.4% in 2013.

Sheep – 238 isolates were identified over the three year period. In 2011 87% of isolates were fully susceptible to all antibiotics and this increased to 94.5% in 2013. Highest levels of resistance were seen to streptomycin, which ranged from 12% in 2011 to 2.2% in 2013. Resistance to ampicillin was 6% in 2012 and reduced to 2.2% in 2013. 4% of isolates were resistant to tetracycline and sulphonamide compounds in 2011 and this reduced to 2.2% in 2013. 1% of isolates were resistant to nalidixic acid and chloramphenicol in 2011 but no resistance to these antibiotics was observed in 2013.

Pigs – 963 isolates were identified over the three year period. In 2011 24% of isolates were fully susceptible and this decreased to 12.5% in 2012 and remained at that level. In 2011 68% of isolates were resistant to sulphonamide compounds and this increased to 84.3% in 2013. Across the three year period increases in resistance were observed to tetracycline (66%-81.5%), streptomycin (61%-74.7%), ampicillin (58%-74.7%), trimethoprim/sulphonamide (42%-55.6%) chloramphenicol (18%-20%), amoxicillin/clavulanic acid (0.7%-5.6%), ceftazidime and nalidixic acid (1%-1.7%). There was a reduction in resistance to apramycin (23-7.9%), gentamicin (22–8.4%) and neomycin (7-2.8%) from 2011-2013. Resistance to ceftazidime and cefotaxime remained static at 0.6-0.7%. No resistance was seen to furazolidone.

Chickens – 2011 isolates were received over the three year period, in 2011 59% of isolates were fully susceptible, and in 2012 this increased to 68.2% and then decreased to 64.2% in 2013. Highest levels of resistance were observed to sulphonamide compounds (16.8-28%). Approximately 20% of isolates were resistant to tetracycline over the three year period, and 7.2-15% of isolates were resistant to streptomycin. An increase in resistance was seen to nalidixic acid (3%-8%), ciprofloxacin (0.6%-1.4%) and furazolidone (0.4%-2.8%). A decrease in resistance was observed to neomycin (4%-2.8%). Resistance to amoxicillin/clavulanic acid, ceftazidime and cefotaxime was observed only in 2011 (0.2% for all). Resistance to apramycin, gentamicin and ampicillin remained static over the three year period.

Turkeys – 966 isolates were identified over the three year period. In 2011 17% of isolates were fully susceptible, in 2012 7.8% were fully susceptible and in 2013 14.9% were fully susceptible. Highest levels of resistance were seen to sulphonamide compounds in 2012 (84.2%), this decreased to 60.3% in 2013. Resistance to trimethoprim/sulphonamide, tetracycline and streptomycin also peaked in 2012 (16.5%, 76.9% and 73% respectively) before decreasing in 2013, (10.7%, 56.5% and 67.8% respectively). Resistance to ampicillin increased over the three year period from 19% to 31% and resistance to nalidixic acid increased from 10% to 20.2%. Ciprofloxacin resistance increased from 2% to 7%. Resistance to furazolidone was observed in 2013 only (0.8%). Resistance was observed to apramycin in 2012 only (0.3%). No resistance to amoxicillin/clavulanic acid, ceftazidime or cefotaxime was observed. Resistance to gentamicin and chloramphenicol remained low (0.2-0.6%) across the three year period.

Ducks – 355 isolates were collected over the three year period, 83% of isolates were fully susceptible in 2011, 73.2% of isolates were fully susceptible in 2012 and 67.5% of isolates were fully susceptible in 2013. Highest levels of resistance were seen to streptomycin (4-25.1 %). Resistance increased to neomycin (2-25.1%), furazolidone (0-23%), tetracycline (6-23.6%) and ampicillin (2-4.7%) from 2011-2012. Resistance to sulphonamide compounds peaked in 2011 at 9.8%. Resistance to nalidixic acid decreased from 10% in 2011 to 0.9% in 2012 then increased to 2.1% in 2013. Resistance to trimethoprim/sulphonamide remained at approximately 4% over the three year period. No resistance was detected to ciprofloxacin, apramycin, gentamicin, amoxicillin/clavulanic acid, ceftazidime or cefotaxime.

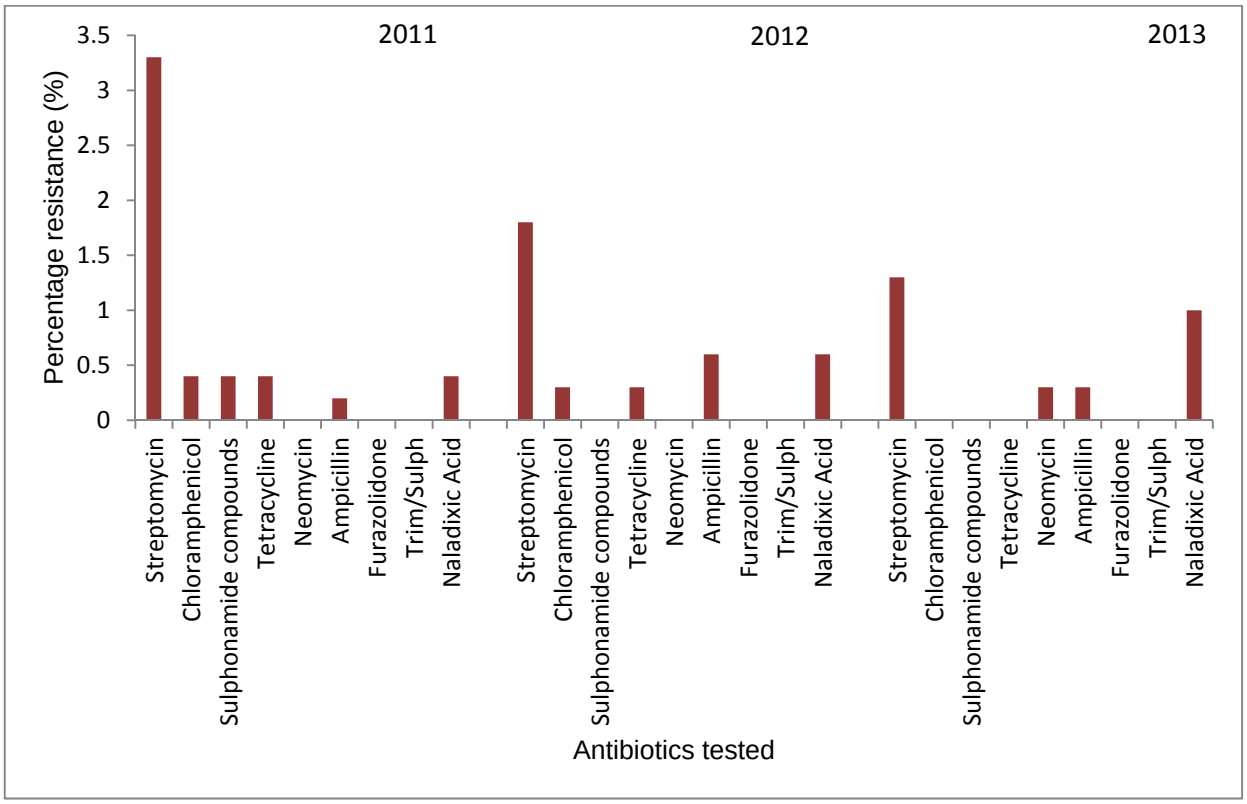
Horses – 153 isolates were identified over the three year period. In 2011 72% of isolates were fully susceptible, in 2012 71.7% of isolate were fully susceptible and in 2013 57.4% of isolates were fully

susceptible. The highest level of resistance was observed against sulphonamide compounds and tetracycline.

Dogs – 149 isolates were identified over the three year period. In 2011 67% were fully susceptible to all antibiotics, in 2012 71.1% were fully susceptible and in 2013 46% were fully susceptible. In 2011 the highest level of resistance was to tetracycline, 28% increasing to 38.9% in 2013. In 2011 resistance to sulphonamide compounds was 25% and resistance to ampicillin was 26%, resistance to both of these antimicrobials increased to 42% in 2013. 15.8%-25% of isolates were resistant to streptomycin. Over the three year period resistance to ciprofloxacin, gentamicin and trimethoprim/sulphonamide increased from 2% to 4%, resistance to nalidixic acid increased to 6% and resistance to chloramphenicol decreased from 5.3% to 2%. Resistance to neomycin and apramycin was 2% in 2011 but was not observed in 2013. No resistance seen to amoxicillin/clavulanic acid, ceftazidime or cefotaxime.

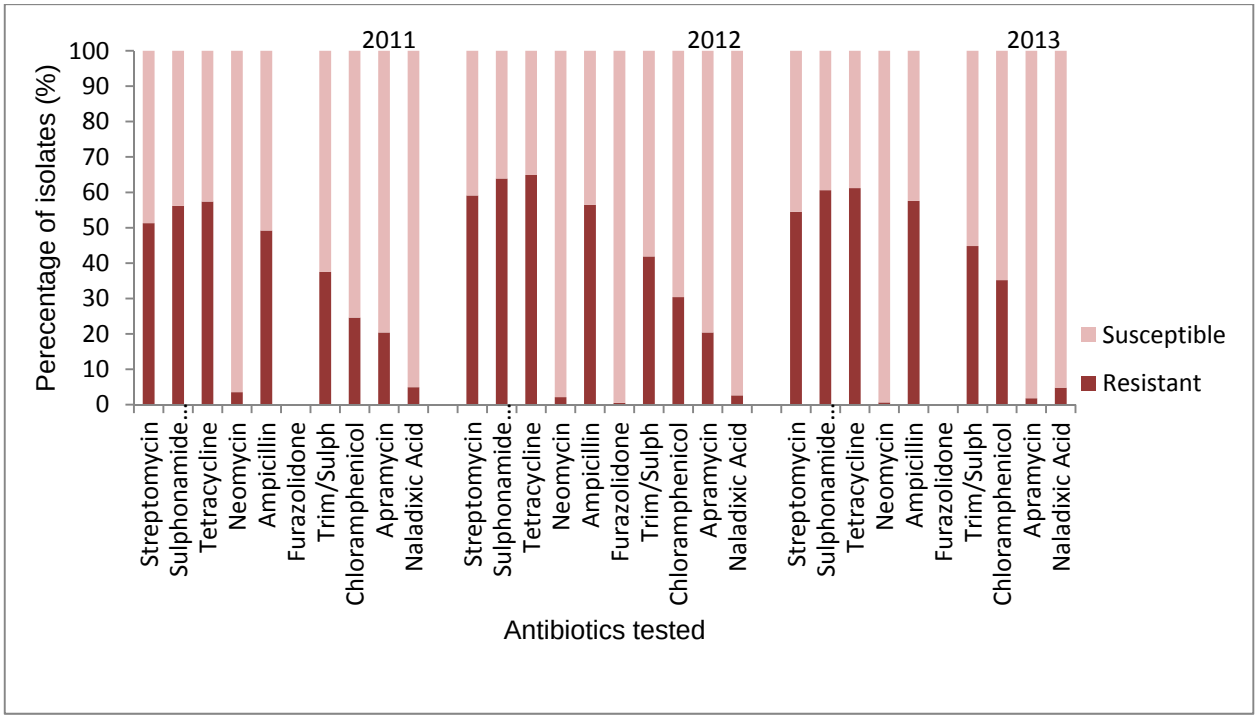
***Salmonella* Dublin** – 1173 isolates were identified over the three year period; in 2011 96% were susceptible to all antibiotics, in 2012 97.2% were fully susceptible and in 2013 96.9% were fully susceptible. This high level of susceptibility has been the situation since surveillance began in 1971. The majority of S. Dublin isolates in 2013 originated from cattle as has been seen for several years. Highest levels of resistance were seen to streptomycin (1.3-3.3%). No resistance was observed to furazolidone or trimethoprim/sulphonamide; resistance to sulphonamide compounds, chloramphenicol and tetracycline ranged from 0.4 to 0%. Resistance to ampicillin ranged from 0.2 to 0.3% and resistance to nalidixic acid ranged from 0.4 to 1% from 2011 to 2013.

Figure 26: Percentage resistance of *Salmonella* Dublin isolates, collected between 2011-2013



***Salmonella* Typhimurium** – 783 isolates were identified over the three year period. In 2011 34.3% were susceptible to all antibiotics, in 2012 27.2% were fully susceptible and in 2013 30% were susceptible to all antibiotics (**Figure 27**). Highest levels of resistance were seen to sulphonamide compounds (56.3–63.9%). Between 2011 and 2013, resistance to tetracycline was observed in 57.4-64.9 % of isolates, 57.6-49.2% of isolates were resistant to ampicillin, 37.5-44.8% were resistant to trimethoprim/sulphonamide, and 24.6-35.2% were resistant to chloramphenicol. In 2011 and 2012 20.4% of isolates were resistant to apramycin, this decreased to 1.8% in 2013. 2.6–4.9% of isolates were resistant to nalidixic acid.

Figure 27: Percentage resistance of *Salmonella* Typhimurium isolates, collected between 2011-2013



Detail on phage types are provided for 2013 only; for more information on phage types prior to 2013 can be found in the annual *Salmonella* in livestock report[13]. The eight most frequent definitive or undefined types subjected to susceptibility testing in 2013 are shown in **Annex 5**, **Figure 29**. 30.3% of all *Salmonella* Typhimurium isolates were sensitive to all of the antimicrobials tested. The generally high level of resistance of *Salmonella* Typhimurium isolates observed in recent years has been partly a reflection of the contribution of DT104 and its variants DT104B and U302, only 15% (7/47) of which were sensitive to all the antimicrobials tested in 2013. Although, the proportion of *Salmonella* Typhimurium isolates comprising DT104 and its variants has declined significantly in recent years, the phage types which are currently prevalent are also frequently resistant. *S*. Typhimurium U288 and DT193 from pigs comprise 13% (21) and 13% (22) of the total numbers of *S*. Typhimurium isolates respectively; none of the U288 and DT193 isolates from pigs were fully susceptible in 2013. AmSSuTTm was the commonest resistance pattern observed in DT193 isolates from pigs (15 isolates) whereas AmCSSuTTm was the commonest resistance pattern recorded in U288 isolates from pigs (13 isolates).

The typical pentavalent resistance pattern AmCSSuT was the commonest resistance pattern seen in *S*. Typhimurium DT104 and 104B isolates occurring in 8/25 isolates; three further isolates had this pentavalent resistance pattern with additional resistances including resistance to trimethoprim/sulphonamides or nalidixic acid. In 2013, 12% (3/25) of DT104 and 104B isolates from all sources were resistant to nalidixic acid

[13] https://www.gov.uk/government/statistics/salmonella-in-livestock-production-in-great-britain-2013

and 4% (1/25) were resistant to sulphamethoxazole/trimethoprim. The sulphamethoxazole/trimethoprim resistant isolate originated from a broiler, whilst the nalidixic acid resistant isolates were all from cattle. No isolates of DT104 were recovered from turkeys in 2012 or 2013 and isolates from this source have commonly shown nalidixic acid resistance in previous years. Nalidixic acid resistance in *S.* Typhimurium DT104 by species of origin is listed in **Table 30** for the main food-producing species. **Table 32** gives the equivalent figures for trimethoprim/sulphamethoxazole resistance by species of origin in *S.* Typhimurium DT104 for the period 2011- 2013.

Considering all definitive types of *S*. Typhimurium, a marked increase in resistance to sulphamethoxazole/trimethoprim from levels of around 16-24% in 1996-2001 to 32.7% to 57.9% in 2002-2007 has been observed and discussed in previous reports. In 2008, the prevalence of resistance to sulphamethoxazole/trimethoprim was 26.4%, though in 2009 this increased to 40.7%; it was 27.1% in 2010, 37.5% in 2011, 41.9% in 2012 and 44.8% in 2013. The contribution from DT104 to this overall figure is shown in **Table 30**. In relation to other phage types of *S*. Typhimurium it has been predominantly isolates from pigs that have accounted for these fluctuations in sulphamethoxazole/trimethoprim resistance (**Table 32**); a high proportion of many definitive types of *S*. Typhimurium isolated from pigs are resistant to sulphamethoxazole/trimethoprim.

Resistance to neomycin was detected in 1/71 isolates of *S*. Typhimurium from pigs (1.4%) in 2013; the isolate was phage type U288. Over the period 2006-2012 the main contribution to the overall levels of neomycin resistance seen in *S.* Typhimurium has come from isolates from pigs belonging to DT193 and U288 or which have been untypable using phages.

Apramycin resistance, which had increased in *S*. Typhimurium in 2011 to 20.4%, was again 20.4% in 2012. This was a notable change in comparison with preceding years where apramycin resistance has been consistently less than 5%. All of the *S*. Typhimurium isolates resistant to apramycin were also resistant to gentamicin. Of the 39 apramycin resistant isolates detected in 2012, 37 originated from pigs and two (belonging to phage type DT193) were from broilers. The apramycin-resistant *S*. Typhimurium isolates from pigs belonged predominantly to phage types DT193 (8 isolates), U288 (13 isolates) and U302 (6 isolates), with only a single isolate of DT104B. Nine isolates were not subjected to phage typing. In 2013, apramycin resistance was 1.8% in *S.* Typhimurium and therefore declined markedly compared to 2012; each apramycin-resistant isolate was also resistant to gentamicin. Two isolates originated from pigs and were DT193; the third was from a non-farmed species and was untypable with phages.

Ciprofloxacin resistance was detected in a single *S*. Typhimurium DT99 isolate from pheasants in 2013; the isolate was also resistant to nalidixic acid.

Multiple antibiotic resistance (i.e. resistance to four or more antimicrobial agents in the panel of 16) was detected in definitive and undefined phage types 104, U288 and U302 from cattle; in phage types 104, 104B and 120 from poultry (i.e. chickens) and in phage types 32, 104, 120, 193, U288 and U302 from pigs. Of the 18 different definitive and undefined phage types detected, five (namely 1, 40, 41b, 66a and 8) were fully susceptible to all of the antimicrobials in the test panel.

Monophasic *Salmonella* serotypes – Fifty-nine isolates of the monophasic *Salmonella* 4,12:i:- were examined, belonging to phage types 40 (n=1), 104b (n=2), 120 (n=3), 193 (n=44) and U311 (n=1); eight isolates were not typable. Most isolates were from pigs (47%) with horses the next most common source of origin (22%). The commonest pattern of resistance observed was AmSSuT occurring in 19/44 DT193 isolates,

the U311 isolate and 3/8 of the isolates which were not typable with phages. 38/44 DT193 isolates (86%) had the basic AmSSuT resistance pattern alone or with one or more additional resistances.

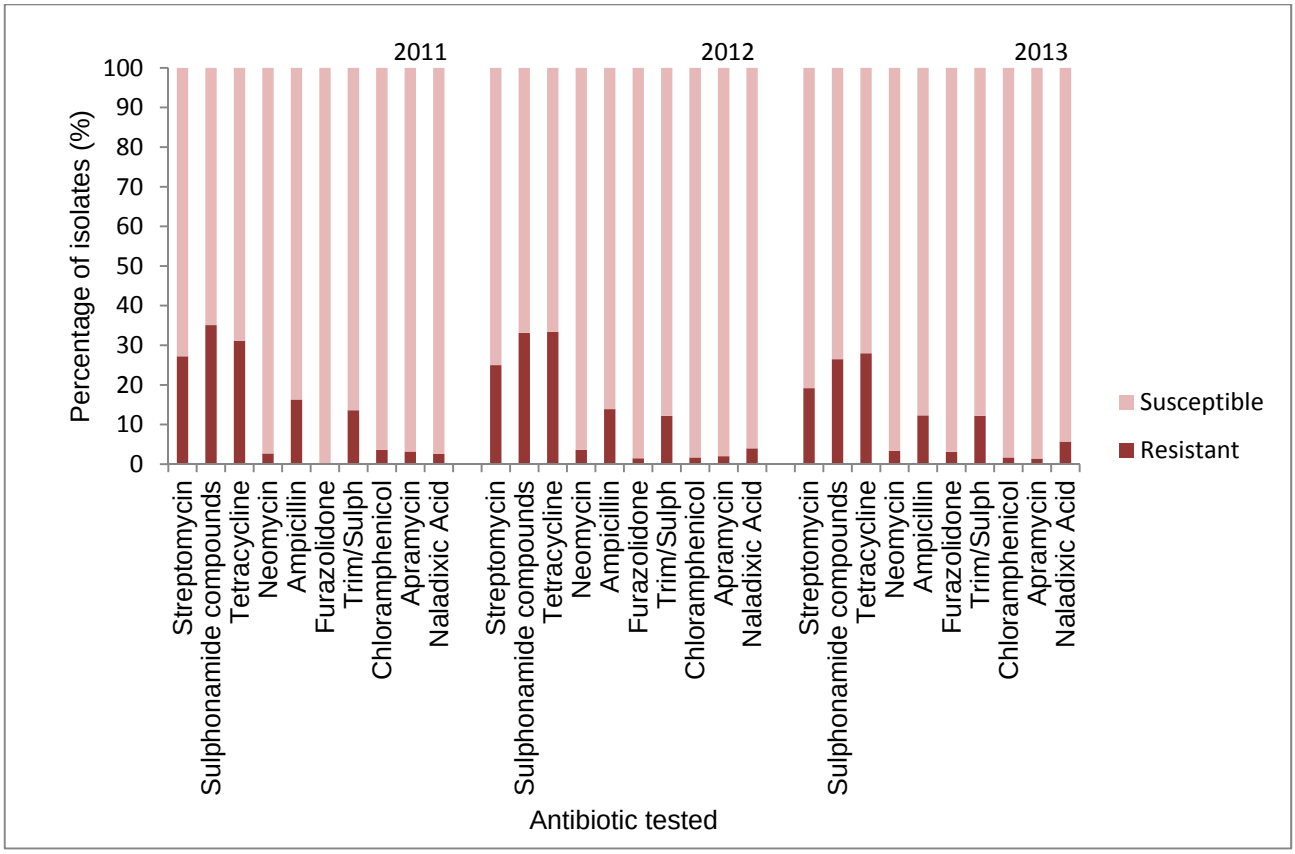
A total of 109 isolates of the monophasic *Salmonella* 4,5,12:i:- were examined, including phage types 8 (n=1), 40 (n=4), 41 (n=3), 104b (n=1), 120 (n=8), 193 (n=73), U310 (n=1), U311 (n=8) and U323 (n=3); seven isolates were untypable. The commonest resistance pattern in DT193 isolates was AmSSuT, occurring in 62% of isolates (45/73). Most isolates of DT193 were from pigs (49%) and cattle (19%).

***Salmonella* other than *S*. Dublin or *S*. Typhimurium** – 6328 isolates were identified over the three year period. In 2011 56.4% of isolates were susceptible to all antibiotics, in 2012 75% were fully susceptible and in 2013 61.2% were fully susceptible. Greatest resistance was seen to sulphonamide compounds with 26.5-35.1% of isolates being resistant. Resistance to tetracycline occurred in 28-31.1% of isolates and 19.2–27.2% of isolates were resistant to streptomycin. Resistance to ampicillin was observed in 12.3-16.3% of isolates and 13.6-12.2% of isolates were resistant to trimethoprim/sulphonamide. The level of resistance to all of those antibiotics decreased over the three year period. Resistance to neomycin increased from 2.7% in 2011 to 3.6% in 2012 and remained at 3.4% in 2013. Resistance to furazolidone increased from 0.2-3.1%. Resistance to nalidixic acid increased from 2.6% in 2011 to 5.7% in 2013. Chloramphenicol resistance ranged from 1.7-3.6% and apramycin resistance ranged from 1.4 to 3.2%.

In 2013 Neomycin resistant isolates originated mainly from ducks (188 isolates; 22.9% resistant) and chickens (832 isolates; 2.9% resistant). The majority of the neomycin-resistant isolates from chickens were *Salmonella* Ohio (the same situation prevailed in 2011 and 2012) with only single isolates of other serotypes resistant to neomycin (Livingstone, Mbandaka, Montevideo and a rough strain). In ducks, serotypes showing resistance to neomycin included *S*. Indiana (35/95 isolates resistant) and *S.* Bredeney (7/7 isolates resistant). The *S.* Indiana isolates from ducks were also frequently resistant to furazolidone (40/95 isolates).

The apparent increase in the prevalence of resistance to streptomycin, sulphonamides and tetracylines from 2009 reflects in part the increased monitoring of turkeys that has occurred in 2010 - 2013 under the Control of *Salmonella* in Turkeys Order. Considering *Salmonella* isolates other than Typhimurium and Dublin from turkeys in 2013 (n=241), 68% were resistant to streptomycin, 61% to sulphonamides and 57% to tetracyclines, similar to the equivalent figures for pigs in 2013 (65-74%), but higher than those for chickens (10-21%) or cattle (14-16%).

Figure 28: Percentage resistance of *Salmonella* spp. isolates, other than *S.* Dublin and *S.* Typhimurium, collected between 2011-2013



Structured surveillance

Salmonella spp.

Structured surveillance programmes were conducted to monitor *Salmonella* in broiler chickens, laying chickens, turkeys and pigs in 2013. Poultry samples were collected under the poultry National Control Programme, in accordance with EFSA recommendations isolates from pigs were collected as part of the pig abattoir survey (see page 64 and 65 for information on the bacterial isolates recovered as part of this sampling).

The isolates were tested using a broth microdilution method to determine their MIC against a range of antibiotics. Epidemiological cut-off values (ECVs) were used to assess susceptibility and resistance, resistance in this case indicating deviation from the wild-type susceptible population. These results were submitted to EFSA in the UK's Trends and Sources Report for 2013 and will be published in the Community Summary Report on Antimicrobial Resistance for 2013 (EFSA and ECDC, in preparation). The pigs originated from all parts of the UK; isolates were recovered from caecal samples and were selected for inclusion in accordance with EFSA's recommendations.

Broilers – 170 isolates were selected retrospectively from isolates submitted as part of the NCP in 2013, 63% of the isolates were fully susceptible to all antibiotics tested. There were no isolates of *S*. Enteritidis recovered from broilers and only two isolates of *S*. Typhimurium, which were resistant to ampicillin, sulphonamides and tetracyclines, with one of the isolates also resistant to chloramphenicol.

Three isolates of monophasic *Salmonella* 4,12:i:- (2) and 4,5,12:i:- (1) were tested from broilers and showed ampicillin, sulphonamide and tetracycline (ASuT) resistance. *[Streptomycin was not tested as it is no longer included in the EFSA panel of antimicrobials].*

Considering all *Salmonella* serovars from broilers, the most prevalent serovar was *S*. Mbandaka (37 isolates) which slightly superseded *S*. Montevideo (34 isolates). Most *S.* Mbandaka isolates (29/37; 78%) were susceptible to the antimicrobials tested; the commonest resistance pattern was resistance to ampicillin, sulphonamides, tetracyclines and trimethoprim which was shown by 8% (3/37) of isolates. The *Salmonella* Montevideo isolates from broilers were mostly (91%) susceptible to the panel of antimicrobials tested, with only two isolates resistant to ampicillin and one to chloramphenicol. *S.* Kedougou was the third most prevalent serovar detected (29 isolates); 41% of isolates (12 isolates) were fully susceptible to the antimicrobial panel, whilst 55% (16 isolates) were resistant to sulphonamides and trimethoprim, with most of these (14 isolates) also resistant to tetracyclines.

Seven *Salmonella* isolates (4% of the total) were resistant to ciprofloxacin and these comprised mainly *Salmonella* Indiana (3) and Senftenberg (2), together with single isolates of Infantis and a rough strain. All of these isolates were also resistant to nalidixic acid. No isolates of *Salmonella* from broilers were resistant to cefotaxime.

Layers – 56 isolates were sampled in 2013, 84% of the isolates were fully susceptible to all antibiotics tested. Three isolates of *S*. Enteritidis were tested and each of these was fully sensitive. There were two isolates of *S*. Typhimurium from layers and both were resistant to ampicillin, streptomycin, sulphonamides and tetracyclines.

Salmonella Senftenberg isolates from layers (9 isolates) were susceptible and a single isolate of *S.* Stanley was resistant to ampicillin, streptomycin, sulphonamides and tetracyclines, though not to nalidixic acid or ciprofloxacin.

Five isolates of monophasic *Salmonella* (4,5,12:i) were examined from layers; four of these showed the typical ASSuT pattern of resistance often seen in such isolates of this serovar, whilst one was fully susceptible.

There were no *Salmonella* isolates recovered from layers in 2013 which were resistant to ciprofloxacin, nalidixic acid or cefotaxime.

Turkeys – 170 isolates were sampled in 2013, 14% were fully susceptible to all antibiotics tested. There were no *S*. Enteritidis or *S.* Typhimurium isolates recovered from turkeys. A single isolate of the monophasic *Salmonella* 4,5,12:i:- was fully susceptible to the antimicrobials tested.

Resistance to the third generation cephalosporin cefotaxime was not detected in *Salmonella* isolates from turkeys. Resistance to ciprofloxacin was detected in 24 isolates (14%) belonging to serotypes Newport (19), Senftenberg (3), Indiana (1) and a rough strain (1). All of these ciprofloxacin-resistant isolates were also resistant to nalidixic acid.

Considering the *S.* Newport isolates recovered from turkeys, 86% (19/22) were resistant to ciprofloxacin, nalidixic acid, ampicillin and streptomycin with a low number of isolates also resistant to sulphonamides, tetracyclines and/or trimethoprim. There were 89 isolates of *Salmonella* Derby from turkeys and 81 (91%) were resistant to streptomycin, sulphonamides and tetracyclines with six additionally resistant to ampicillin

and one additionally resistant to trimethoprim. There were 23 isolates of *Salmonella* Kedougou examined, all of which were resistant to sulphonamides and most of which 21/23 were also resistant to tetracyclines. There were no isolates of *S.* Stanley from turkeys amongst the *Salmonella* isolates tested in 2013.

Pigs – 147 isolates were sampled in 2013, 26% were fully susceptible to all antibiotics tested. The isolates were selected in accordance with EFSA's recommendations for monitoring (one isolate *per* serovar *per* epidemiological unit *per* year). Considering *S*. Typhimurium in pigs, 31 isolates were available from the surveillance programme in 2013 and only three isolates were fully sensitive to the panel, with a further single isolate resistant only to tetracyclines. Ampicillin, streptomycin, sulphonamide and tetracycline resistance was common occurring in 81-87% of *S*. Typhimurium isolates, with chloramphenicol resistance less common, occurring in 52% of isolates. The proportion (21%) of *S*. Typhimurium isolates contributing to the total number of *Salmonella* isolates tested influences the fully susceptible figure for all serotypes, because this serotype commonly shows antimicrobial resistance. Resistance to fluoroquinolones or third generation cephalosporins were not detected in these *S*. Typhimurium isolates.

In 2013, the next most prevalent serovars in pigs after *S*. Typhimurium were the monophasic *Salmonella* 4,12:i:- and 4,5,12:i:- which contributed 25 isolates each to the total and commonly showed resistance to ampicillin, streptomycin, sulphonamides and tetracyclines. Monophasic salmonellas with the antigenic structure 4,5,12:i:- and an ASSuT pattern of resistance appear to be increasing in prevalence and importance in several parts of Europe and have been particularly associated with pigs. Resistance to gentamicin, chloramphenicol and trimethoprim was observed in approximately 20-35% of both of these monophasic *Salmonella* serotypes. Single isolates of 4,12:i:- and 4,5,12:i:- were resistant (microbiological breakpoint) to fluoroquinolones; the only other serovar displaying ciprofloxacin resistance was *S*. Agona, where resistance was detected in a single isolate.

There were no isolates of *S*. Enteritidis recovered from pigs. Four isolates of *Salmonella* Stanley were recovered from pigs and these were resistant to ampicillin, streptomycin, sulphonamides and tetracyclines, though not to nalidixic acid or ciprofloxacin. *Salmonella* Bovismorbificans, of which 17 isolates were available, were generally either fully susceptible to the panel or showed resistance to ampicillin, chloramphenicol, streptomycin, sulphonamides, tetracyclines, trimethoprim and gentamicin. *Salmonella* Reading was generally susceptible to the panel of antimicrobials tested, with only a single isolate of six tested showing resistance to tetracyclines; the situation was similar in the serovar *Salmonella* London, where one of three isolates showed resistance to tetracyclines only. *Salmonella* Derby isolates (N=18) were relatively susceptible, though 33-45% were resistant to tetracyclines, sulphonamides and trimethoprim. Similarly *S*. Rissen isolates (N=3) were resistant to tetracyclines only. *Salmonella* Panama (n=5) did not show resistance to the panel of antimicrobials tested; *S*. Goldcoast (N=3) was also relatively susceptible, with only a single isolate resistant to tetracyclines; however, this serotype has shown multiple resistance in the recent past in the UK. MIC values for selected antibiotics can be found in **Annex 6.**

Campylobacter spp.

Campylobacter monitoring of broiler slaughter batches, based on the EU technical specifications in Decision 2007/516/EC was performed in 2013. Isolates of *Campylobacter jejuni* and *C. coli* were collected from positive slaughter batches of caeca from UK broilers. Selection of isolates for susceptibility testing was based on the criteria laid down in EU technical specifications (Decision 2007/516/EC of 21/7/2007) and susceptibility testing was performed in accordance with the recommendations of EFSA (EFSA 2007). The isolates were tested using a standardised broth microdilution method, to determine their MIC against a range of antibiotics. Epidemiological cut-off values (ECVs) were used to assess susceptibility as described in Decision 2007/516/EC. These results were submitted to EFSA in the UK's Trends and Sources Report for 2013 and will be published in the Community Summary Report on Antimicrobial Resistance for 2013 (EFSA and ECDC, in preparation). The caecal samples from broilers were collected throughout the year.

Campylobacter coli isolates from pigs were obtained from the national abattoir survey of pigs (Data Sources page 14); the majority of porcine caeca were collected over a three-four month period in 2013.

Broilers – 94 isolates were sampled in 2013, 33 isolates were *C. coli* and 61 were *C .jejuni.* Ciprofloxacin resistance was demonstrated in 31% (19/61) of *C. jejuni* isolates from broilers and all of these isolates were also resistant to nalidixic acid. Tetracycline resistance was observed in 48% (29/61) of isolates, whereas resistance to erythromycin, streptomycin or gentamicin was not detected in *C. jejuni* from broilers.

Considering *C. coli* from broilers, 42% (14/33) of isolates were resistant to ciprofloxacin and nalidixic acid. A single isolate was resistant to erythromycin and this isolate was also resistant to ciprofloxacin/nalidixic acid. 55% of isolates (18/33) were resistant to tetracyclines, whilst 15% (5/33) were resistant to streptomycin and none to gentamicin.

Pigs – 141 isolates were sampled in 2013, *C. coli* was the only *Campylobacter* species examined from pigs for antimicrobial susceptibility. Ciprofloxacin resistance was detected in 13% of porcine *C. coli* isolates and all of these were also resistant to nalidixic acid. Three further isolates were resistant to nalidixic acid, but susceptible to ciprofloxacin. No resistance to gentamicin was detected, whereas 67% (94/141) of isolates were resistant to streptomycin and 79% (112/141) were resistant to tetracyclines. Erythromycin resistance was observed in 27% (38/141) of isolates. Nine isolates (6%) were co-resistant to both ciprofloxacin and erythromycin. MIC results can be found in **Annex 6**.

Escherichia coli

Escherichia coli isolates from pigs were obtained from the national abattoir survey of pigs (see data sources); 637 porcine caeca were collected in 2013. Isolate selection and susceptibility testing was performed in accordance with EFSA's recommendations (EFSA, 2008).

Pigs – 157 caeca from pigs from different farms were randomly selected and *E. coli* was cultured from each sample. AST was carried out on one randomly-selected *E. coli* isolate from each culture. Considering the antimicrobials of particular public health relevance and microbiological resistance assessed using ECVs, cefotaxime resistance was observed in 0.6% of isolates and ciprofloxacin resistance in 1.3% of isolates. *[The single isolate resistant to cefotaxime was not co-resistant to ciprofloxacin].* Considering the other antimicrobials tested, resistance was observed to tetracyclines (67%), sulphonamides (52%), trimethoprim (41%), streptomycin (37%), ampicillin (31%), chloramphenicol (22%) and gentamicin (3%).

All 637 samples were also cultured on several selective media to detect carriage of CTX-M and other ESBL-producing *E. coli* in healthy animals. Presumptive ESBL *E. coli* were isolated from 149 samples (23.4%). Further molecular testing confirmed that 22% (95% CI 17.8–26.1) of the pigs carried *E. coli* producing CTX-M enzymes [comprising enzyme types 1 (18.7% of pigs), 3 (0.2%), 14 (0.5%), 15 (1.4%), 27 (0.5%), 32 (0.5%) and 55 (0.3%)] and 2.2% (95% CI 0.8–3.6) of the pigs carried *E. coli* producing SHV-12. Five pigs carried both CTX-M- and SHV-12-producing *E. coli* in different *E. coli* isolates selected from the same animal.

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Annex 1 – Sales Data Caveats

IMPORTED & EXPORTED SALES

In previous reports the VMD has presented data showing the amounts of active ingredients imported into the UK via the Special Import Certificate (SIC) and Special Treatment Certificate (STC) schemes. When the 2010 report (containing 2009 sales data) was being prepared, the VMD undertook routine validation of the SIC/STC data. We found that applicants were frequently duplicating applications and that some other errors had occurred when applications were made. These factors meant that the calculated SIC/STC summary data over-reported imports.

The VMD is working closely with industry to obtain suitable data to identify the amount of active ingredient sold to UK feed mills but then exported outside the UK.

CASCADE PRESCRIBING

The Cascade is a legislative provision in the Veterinary Medicines Regulations that allows a veterinary surgeon to prescribe unauthorised medicines that would not otherwise be permitted e.g. imported medicines or a medicine licensed for human use. The principle of the Cascade is that, if there is no suitable veterinary medicine authorised in the UK to treat a condition, the veterinary surgeon responsible for the animal may in particular, to avoid causing unacceptable suffering, treat with an unauthorised medicine. Food producing animals may only be treated under the Cascade with medicines whose pharmacologically active substances are listed in the Table of Allowed Substances in Commission Regulation EU No 37/2010.

The data used in this report do not include data on sales of human antimicrobials for use in animals in accordance with the prescribing cascade, as currently there is no mechanism by which such information can be obtained. However, it is not thought that use of human products in food producing species is extensive, due to issues with withdrawal periods.

The VMD continues to explore methods that can accurately incorporate information on the amounts of antimicrobials imported into/exported from the UK and methods that can accurately incorporate sales of antimicrobials licensed for humans that are sold for animal use under the Cascade prescribing system.

Annex 2 – European Surveillance of Veterinary Antimicrobial Consumption (ESVAC)

The European Commission (EC) has requested the European Medicines Agency (EMA) to take the lead in collating data collected on the use of antimicrobial agents in animals in the European Union. The EMA is developing a harmonised approach for the collection and reporting of data based on national sales figures. This is designed to be comparable with usage data of human antimicrobials.

Published ESVAC reports are available from:

http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/document_listing/document_listing_000302.jsp

The ESVAC publication report sales figures in a slightly different way to the approach used in the UK. Currently the ESVAC project utilises data on antimicrobial products with specific Anatomical Therapeutic Codes (ATCs), and these do not at the current time encompass the same breadth of products as the UK report. In addition, ESVAC methods for calculation of active ingredient relate directly to information held within the Summary of Product Characteristics (SPC) which does not always mean the calculation will report quantity of active moiety. The UK calculation always converts ingredients to the active moiety. Therefore, figures reported in the UK report(s) are not directly comparable with the UK data cited in the ESVAC report(s). We intend to continue to use the current reporting format for the UK sales data report, but periodically review the UK report as the ESVAC project develops.

Annex 3 – Amendments to UK-VARSS 2012

Total sales and mg/ PCU data have been updated since publication of the UK-VARSS 2012 report in November 2013. The data have been revised following the resubmission of 2012 sales data by one Market Authorisation Holder. As a result the following amendments have now been included in the report:

1. Figure 1: Milligrams (mg) of active ingredient sold for food producing animals per population correction unit (PCU)

    1.1. The total weight of active ingredient sold for food producing species per PCU in 2012 has increased from 55 mg/PCU to 60 mg/PCU
    1.2. The total weight of active ingredient sold for use in pigs and poultry per PCU in 2012 has increased from 173 mg/PCU to 192 mg/PCU

2. Table 5 & Figure 4: Sales (tonnes active ingredient) of total antibiotic products by chemical grouping

    2.1. Total sales of antibiotic products in 2012 has increased from 409 to 445 tonnes of active ingredient
    2.2. Sales of tetracycline products in 2012 have increased from 187 tonnes to 190 tonnes
    2.3. Sales of trimethoprim/sulphonamide products in 2012 increased from 65 tonnes to 80 tonnes
    2.4. Sales of products in the “Other” category in 2012 have increased from 12 to 21 tonnes.

3. Table 6 and Figure 5: Sales (tonnes active ingredient) of total antibiotics by route of administration

    3.1. Sales of antibiotic products as medicated feeding stuff in 2012 have increased from 245 to 275 tonnes
    3.2. Sales of oral/ water products have increased in 2012 from 112 to 117 tonnes
    3.3. Sales of injectable products in 2012 increased from 46 tonnes to 47 tonnes

4. Table 7: Sales (tonnes active ingredient) of antibiotics, in the categories of food animals only, non-food animals only and combined food and non- food animals

    4.1. Sales of products authorised for use in food animals only in 2012 have increased from 349 tonnes to 381 tonnes
    4.2. Sales of products authorised for use in a combination of both food and non-food animals in 2012 have increased from 21 to 29 tonnes

5. Table 8: Sales (tonnes active ingredient) of total antibiotics for food-producing animals only by species

    5.1. Sales of products authorised for use in pigs only in 2012 have increased from 53 to 65 tonnes
    5.2. Sales of products authorised for use in pigs and poultry combined only have increased from 225 to 245 tonnes

Annex 4 – Sales of antimicrobials other than antibiotics

Antiprotozoals

The majority of antiprotozoal products authorised in the UK are for use only in food-producing animal species.

Antiprotozoals are products primarily used in the treatment and/or prevention of parasitic protozoal infections, (e.g. *Eimeria* spp). The majority of antiprotozoal products are coccidiostats, which are used for the prevention of coccidiosis, (a disease caused by parasitic protozoal organisms). They are not related to any antimicrobial product currently used in human therapy and are used exclusively in animals, particularly poultry. Current evidence does not link the use of these to the development of resistance in bacteria to any therapeutic antibiotics.

Table 9: Sales (tonnes active ingredient) of antiprotozoals in the UK 2009–2013

	2009	2010	2011	2012	2013
Total coccidiostats	234	240	277	301	289
- *Ionophores*	*169*	*175*	*201*	*212*	*209*
- *Non-ionophores*	*65*	*65*	*76*	*89*	*80*
Other antiprotozoals	3	15	6	5	6
Total Antiprotozoals	237	255	283	306	295

Antifungals

The sales of antifungal products reported to the VMD under the drug classifications imidazoles, triazoles, griseofulvin, aliphatic halogenitros and polyene macrolides were as follows: 7.6, 10.6, 8.7, 6.2 and 10.7 tonnes of active ingredient for the years 2009-13 respectively. There were 12 products authorised to treat veterinary antifungal infections sold in 2013, 11 of which are indicated for use only in non-food animals.

Annex 5 – Surveillance data

Table 10: Susceptibility of *Escherichia coli*/coliforms from different food producing animals (all ages) for 2011-2013

	Cattle			Pigs			Sheep		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	888 / 64%	901 / 69%	782 / 73%	180 / 39%	134 / 59%	102 / 88%	132 / 20%	165 / 31%	225 / 46%
Amikacin	1/703 0.1%	8/757 1%	4/706 1%	-	-	-	1/61 2%	0/82 0%	0/150 0%
Amoxicillin/ clavulanic acid	356/810 44%	454/850 53%	385/780 49%	5/78 6%	11/104 11%	3/76 4%	14/121 12%	35/155 23%	48/224 21%
Ampicillin	624/810 77%	673/850 79%	617/780 79%	79/173 46%	88/131 67%	51/101 50%	52/121 43%	75/155 48%	125/224 56%
Apramycin	50/791 6%	59/831 7%	50/761 7%	22/173 13%	21/131 16%	14/101 14%	1/105 1%	2/143 1%	3/204 1%
Cefotaxime	125/712 18%	117/760 15%	94/707 13%	4/4	3/4	-	1/61 2%	5/82 6%	4/150 3%
Cefpodoxime	2/24 8%	2/19	0/19	4/173 2%	4/131 3%	4/101 4%	0/18	0/13	0/20 0%

Ceftazidime	58/712 8%	51/760 7%	52/707 7%	4/4	1/4	-	1/61 2%	3/82 4%	1/150 1%
Chloramphenicol	377/703 54%	440/757 58%	386/706 55%	-	-	-	7/61 11%	27/82 33%	54/150 36%
Doxycycline	-	-	-	34/78 44%	57/104 55%	45/76 59%	-	-	-
Enrofloxacin	86/810 11%	81/850 10%	93/780 12%	16/173 9%	10/131 8%	8/101 8%	0/121 0%	1/155 1%	8/224 4%
Florfenicol	239/727 33%	258/776 33%	262/724 36%	0/78 0%	7/104 7%	5/76 7%	4/76 5%	5/95 5%	28/169 17%
Neomycin	322/786 41%	325/831 39%	332/761 44%	14/173 8%	16/131 12%	10/101 10%	9/106 8%	16/142 11%	36/205 18%
Spectinomycin	349/791 44%	402/831 48%	380/761 50%	66/173 38%	38/131 29%	34/101 34%	38/105 36%	62/143 43%	108/204 53%
Streptomycin	484/703 69%	461/757 61%	439/706 62%	34/78 44%	55/104 53%	33/76 43%	27/64 42%	43/82 52%	84/151 56%
Tetracycline	607/810 75%	659/850 78%	595/780 76%	112/173 65%	95/131 73%	75/101 74%	62/121 51%	86/155 55%	153/224 68%
Trimethoprim/	353/810	387/850	359/780	86/173	63/131	51/101	20/121	28/155	62/224

Sulphonamide	44%	46%	46%	50%	48%	50%	17%	18%	28%

	Chickens			Turkeys			All Five Species		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	320 / 21%	338 / 29%	289 / 15%	32 / 41%	33 / 27%	6	1552 / 48%	1571 / 54%	1404 / 720
Amikacin	-	-	-	-	-	-	2/764 0.3%	8/839 1%	4/856 0.5%
Amoxicillin/ clavulanic acid	40/216 19%	55/251 22%	11/215 5%	1/6	0/9	0/1	416/1231 34%	555/1369 41%	447/1296 34%
Ampicillin	119/320 37%	166/338 49%	94/289 33%	12/32 38%	18/33 55%	5/6	886/1456 61%	1020/1507 68%	892/1400 64%
Apramycin	6/320 2%	23/338 7%	18/288 6%	0/32 0%	2/33 6%	0/6	79/1421 6%	107/1476 7%	85/1360 6%
Cefotaxime	-	-	-	-	-	-	126/773 16%	125/846 15%	98/857 11%
Cefpodoxime	29/320 9%	49/338 14%	23/288 8%	0/32 0%	0/33 0%	0/6	33/525 6%	55/534 10%	27/434 6%

Ceftazidime	-	-	-	-	-	-	59/773 8%	55/846 7%	53/857 6%
Chloramphenicol	-	-	-	-	-	-	384/764 50%	467/839 56%	440/856 51%
Doxycycline	64/320 20%	73/338 22%	40/289 14%	23/32 72%	15/33 45%	1/6	121/430 28%	145/475 31%	86/371 23%
Enrofloxacin	7/320 2%	9/338 3%	5/289 2%	8/32 25%	2/33 6%	0/6	117/1456 8%	103/1507 7%	114/1400 8%
Florfenicol	-	0/3	-	-	0/1	-	243/881 28%	270/969 28%	295/969 30%
Neomycin	6/216 3%	12/248 5%	20/214 9%	1/6	0/8	0/1	352/1287 27%	369/1360 27%	398/1282 31%
Spectinomycin	37/320 12%	42/338 12%	43/288 15%	7/32 22%	5/33 15%	0/6	497/1421 35%	549/1476 37%	565/1360 42%
Streptomycin	-	0/3	-	-	0/1	-	545/845 64%	559/947 59%	556/933 60%
Tetracycline	125/320 39%	146/338 43%	104/289 36%	28/32 88%	19/33 58%	5/6	934/1456 64%	1005/1507 67%	932/1400 67%
Trimethoprim/	52/320	61/338	36/289	11/32	7/33	0/6	522/1456	546/1507	508/1400

Sulphonamide	16%	18%	12%	34%	21%	36%	36%	36%

Note: The large differences in the prevalence of resistance commonly observed in cattle, sheep and pigs of different ages mean that the level of resistance shown in these summary tables for animals of all ages, may reflect to a significant degree the proportions of each age-class of animal which have contributed to the total. Similar considerations can apply to the contribution of different animal production types, for example layer and broiler chickens. These considerations should be borne in mind when interpreting these summary figures. These totals exclude the *E. coli* isolates from bovine mastitis which can be found at **Table 14**.

Percentage resistant is not given where there are less than 20 isolates.

Table 11: Cattle *E. coli*/coliforms susceptibility by age group

	Neonatal			Pre-weaning			Adult		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available/ % multi-resistant	727 / 66%	735 / 70%	630 / 75%	84 / 61%	80 / 66%	86 / 70%	21 / 29%	14	17
Amikacin	1/613 0%	6/644 1%	3/599 1%	0/45 0%	2/51 4%	0/61 0%	0/1	0/6	0/3
Amoxicillin / Clavulanic acid	305/654 47%	391/691 57%	330/629 52%	32/82 39%	31/79 39%	36/86 42%	2/19	2/13	2/16
Ampicillin	523/654 80%	560/691 81%	511/629 81%	62/82 76%	60/79 76%	69/86 80%	6/19	5/13	5/16
Apramycin	38/650 6%	51/683 7%	39/621 6%	7/74 9%	2/72 3%	5/78 6%	0/12	1/11	1/14
Cefotaxime	104/619 17%	94/645 15%	75/599 13%	11/45 24%	11/51 22%	12/61 20%	3/4	1/7	0/4
Ceftazidime	46/619 7%	42/645 7%	46/599 8%	5/45 11%	3/51 6%	4/61 7%	2/4	0/7	0/4
Chloramphenicol	336/613 55%	377/644 59%	333/599 56%	21/45 47%	33/51 65%	34/61 56%	0/1	2/6	2/3

Enrofloxacin	64/654 10%	67/691 10%	75/629 12%	12/82 15%	5/79 6%	9/86 10%	1/19	1/13	2/16
Florfenicol	202/621 33%	205/652 31%	215/606 35%	23/54 43%	29/58 50%	33/69 48%	0/8	1/8	1/5
Neomycin	267/646 41%	256/683 37%	276/621 44%	29/73 40%	34/72 47%	38/78 49%	2/12	2/11	1/14
Spectinomycin	298/650 46%	343/683 50%	329/621 53%	29/74 39%	30/72 42%	28/78 36%	2/12	3/11	4/14
Streptomycin	428/613 70%	383/644 59%	372/599 62%	28/45 62%	37/51 73%	43/61 70%	0/1	3/6	2/3
Tetracycline	509/654 78%	541/691 78%	489/629 78%	57/82 70%	67/79 85%	67/86 78%	5/19	5/13	7/16
Trimethoprim / Sulphonamide	291/654 44%	312/691 45%	290/629 46%	40/82 49%	39/79 49%	46/86 53%	4/19	4/13	4/16

Note: The percentage resistance is not given where there are less than 20 isolates. Where the animal's age was not recorded at the time of submission the isolate is not included, therefore the total number of isolates reported in this table may differ from table 10

Table 12: Pig *E. coli*/coliforms susceptibility by age group

	Neonatal			Post-weaning			Adult		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	37 / 32%	47 / 66%	28 / 46%	76 / 38%	45 / 62%	36 / 69%	12	4	6
Amoxicillin / Clavulanic acid	0/13	6/44 14%	1/18	1/36 3%	3/33 9%	2/31 6%	1/8	0/2	0/4
Ampicillin	18/37 49%	31/45 69%	16/28 57%	31/71 44%	36/45 80%	20/35 57%	4/11	0/4	3/6
Apramycin	0/37 0%	3/45 7%	0/28 0%	17/71 24%	17/45 38%	9/35 26%	0/11	0/4	1/6
Cefpodoxime	2/37 5%	4/45 9%	1/28 4%	0/71 0%	0/45 0%	1/35 3%	0/11	0/4	0/6
Doxycycline	5/13	24/44 55%	11/18	14/36 39%	20/33 61%	20/31 65%	3/8	0/2	1/4
Enrofloxacin	5/37 14%	5/45 11%	3/28 11%	5/71 7%	0/45 0%	2/35 6%	1/11	0/4	0/6
Florfenicol	0/13	1/44 2%	0/18	0/36 0%	3/33 9%	4/31 13%	0/8	0/2	0/4

Neomycin	0/37 0%	3/45 7%	2/28 7%	8/71 11%	9/45 20%	5/35 14%	1/11	0/4	1/6
Spectinomycin	16/37 43%	11/45 24%	9/28 32%	26/71 37%	18/45 40%	17/35 49%	2/11	0/4	1/6
Streptomycin	5/13	23/44 52%	9/18	14/36 39%	17/33 52%	16/31 52%	4/8	0/2	0/4
Tetracycline	27/37 73%	33/45 73%	18/28 64%	45/71 63%	35/45 78%	26/35 74%	5/11	1/4	4/6
Trimethoprim / Sulphonamide	20/37 54%	26/45 58%	14/28 50%	34/71 48%	22/45 49%	21/35 60%	5/11	1/4	2/6

Note: The percentage resistance is not given where there are less than 20 isolates. Where the animal's age was not recorded at the time of submission the isolate is not included, therefore the total number of isolates reported in this table may differ from Table 10

Table 13: Sheep *E. coli*/coliforms susceptibility by age group

	Neonatal			Pre-weaning			Adult		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	75 / 31%	119 / 38%	174 / 54%	22 / 18%	19	15	14	18	18
Amoxicillin / Clavulanic acid	12/66 18%	30/109 28%	44/173 25%	1/21 5%	4/19	2/15	0/14	1/18	0/18
Ampicillin	35/66 53%	60/109 55%	108/173 62%	9/21 43%	8/19	4/15	3/14	4/18	6/18
Apramycin	1/66 2%	1/106 1%	3/170 2%	0/19	0/14	0/10	0/9	0/15	0/9
Cefotaxime	1/49 2%	5/76 7%	4/139 3%	0/9	0/4	0/3	-	-	0/1
Ceftazidime	1/49 2%	3/76 4%	1/139 1%	0/9	0/4	0/3	-	-	0/1
Chloramphenicol	7/49 14%	25/76 33%	50/139 36%	0/9	1/4	2/3	-	-	0/1
Enrofloxacin	0/66 0%	1/109 1%	6/173 3%	0/21 0%	0/19	0/15	0/14	0/18	1/18

Florfenicol	2/49 4%	3/80 4%	24/142 17%	0/11	1/9	2/8	1/4	0/3	0/10
Neomycin	7/66 11%	12/105 11%	33/170 19%	2/19	2/14	2/10	0/10	1/15	0/9
Spectinomycin	26/66 39%	55/106 52%	101/170 59%	8/19	3/14	2/10	0/9	3/15	2/9
Streptomycin	22/51 43%	40/76 53%	77/139 55%	3/9	3/4	2/3	0/1	-	1/1
Tetracycline	37/66 56%	65/109 60%	130/173 75%	10/21 48%	9/19	9/15	4/14	5/18	7/18
Trimethoprim / Sulphonamide	14/66 21%	25/109 23%	54/173 31%	3/21 14%	2/19	4/15	0/14	0/18	2/18

Note: The percentage resistant is not given where there are less than 20 isolates. Where the animal's age was not recorded at the time of submission the isolate is not included, therefore the total number of isolates reported in this table may differ from Table 10

Table 14: Gram-negative Mastitis Pathogens in Cattle

	E. coli / coliforms			*Klebsiella pneumoniae*			*Pseudomonas aeruginosa*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available/ % multi-resistant	258 / 7%	205 / 5%	159 / 8%	8	3	12	9	4	5
Amoxicillin / Clavulanic acid	12/258 5%	11/205 5%	13/159 8%	0/8	0/3	3/12	9/9	4/4	5/5
Ampicillin	52/258 20%	56/205 27%	43/159 27%	4/8	2/3	11/12	9/9	4/4	5/5
Cefotaxime	-	-	-	-	-	3/4	1/6	3/4	0/5
Cefpodoxime	2/258 1%	1/205 0%	1/159 1%	0/6	0/3	3/9	6/6	4/4	5/5
Ceftazidime	-	-	-	-	-	3/4	0/6	0/4	0/5
Cefalexin	-	-	-	-	-	3/3	6/6	4/4	5/5
Enrofloxacin	2/258 1%	4/205 2%	0/159 0%	0/8	0/3	0/12	2/9	0/4	0/5
Neomycin	12/258 5%	12/205 6%	11/159 7%	0/8	0/2	1/9	2/6	2/4	1/4
Streptomycin	23/258	17/205	10/159	0/6	0/2	2/7	0/3	0/4	0/4

	9%	8%	6%						
Tetracycline	23/258 9%	26/205 13%	13/159 8%	0/8	0/3	4/12	8/9	4/4	5/5
Trimethoprim / Sulphonamide	19/258 7%	11/205 5%	13/159 8%	0/8	0/3	1/12	8/9	3/4	4/5

Note: The percentage multi-resistant is not given where there are less than 20 isolates.

Table 15: Gram-positive Mastitis Pathogens in Cattle

	Streptococcus agalactiae			*Streptococcus dysgalactiae*			*Streptococcus uberis*			*Staphylococcus aureus*			*Trueperella pyogenes*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	1	-	1	83 / 0%	69 / 0%	47 / 0%	329 / 0%	256 / 2%	120 / 3%	216 / 1%	147 / 4%	106 / 6%	37 / 0%	22 / 0%	11 / 0%
Amoxicillin / Clavulanic acid	0/1	-	0/1	0/83 0%	0/69 0%	0/47 0%	0/329 0%	0/256 0%	0/120 0%	24/216 11%	21/147 14%	26/106 25%	0/37 0%	0/22 0%	0/11
Ampicillin	0/1	-	0/1	0/83 0%	0/69 0%	0/47 0%	0/329 0%	0/256 0%	1/120 1%	85/216 39%	57/147 39%	31/106 29%	0/37 0%	0/22 0%	0/11
Neomycin	1/1	-	1/1	23/81 28%	17/65 26%	4/47 9%	178/329 54%	168/255 66%	83/119 70%	0/216 0%	1/147 1%	0/106 0%	14/37 38%	7/22 32%	2/11
Novobiocin	0/1	-	0/1	4/81 5%	3/65 5%	4/47 9%	4/329 1%	24/255 9%	8/119 7%	0/216 0%	0/147 0%	0/106 0%	1/37 3%	0/22 0%	0/11
Tetracycline	0/1	-	0/1	70/83 84%	55/69 80%	43/47 91%	107/329 33%	127/256 50%	70/120 58%	7/216 3%	10/147 7%	13/106 12%	19/37 51%	12/22 55%	7/11
Tylosin	0/1	-	0/1	3/83 4%	6/69 9%	4/47 9%	44/329 13%	47/256 18%	24/120 20%	3/216 1%	1/147 1%	1/106 1%	1/37 3%	5/22 23%	0/11

Note: The percentage resistant is not given where there are less than 20 isolates.

Table 16: Cattle, all ages, Respiratory Pathogens including *Trueperella pyogenes*

	Pasteurella multocida			*Mannheimia haemolytica*			*Histophilus somni*			*Trueperella pyogenes*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available/ % multi-resistant	72 / 0%	56 / 0%	39 / 3%	49 / 0%	26 / 0%	17 / 0%	37 / 0%	26 / 4%	14 / 0%	36 / 0%	23 / 0%	12
Amoxicillin / Clavulanic acid	0/72 0%	0/56 0%	0/39 0%	0/49 0%	0/26 0%	0/17	0/37 0%	1/26 4%	0/14 0%	0/36 0%	0/23 0%	0/12
Ampicillin	0/72 0%	0/56 0%	3/39 8%	0/49 0%	0/26 0%	0/17	0/37 0%	1/26 4%	0/14 0%	0/36 0%	0/23 0%	0/12
Cefalexin	0/1	-	0/1	0/1	-	-	-	0/1	-	0/36 0%	0/23 0%	0/12
Cefpodoxime	0/72 0%	0/56 0%	1/39 3%	1/49 2%	0/26 0%	0/17	0/37 0%	1/26 4%	0/14 0%	-	-	-
Enrofloxacin	0/72 0%	0/56 0%	0/39 0%	0/49 0%	0/26 0%	0/17	0/37 0%	0/26 0%	0/14 0%	-	-	-
Florfenicol	0/63 0%	0/48 0%	0/33 0%	0/49 0%	0/26 0%	0/17	0/36 0%	0/26 0%	0/14 0%	0/36 0%	1/23 4%	0/12
Tetracycline	37/72	18/56	19/39	1/49	2/26	1/17	0/37	1/26	0/14	26/36	13/23	7/12

	51%	32%	49%	2%	8%		0%	4%		72%	57%	
Trimethoprim / Sulphonamide	0/72 0%	0/56 0%	0/39 0%	0/49 0%	1/26 4%	0/17	1/37 3%	0/26 0%	0/14	18/36 50%	8/23 35%	6/12
Tylosin	0/1	-	-	-	-	-	-	0/1	-	4/36 11%	2/23 9%	0/12

Note: The percentage resistant is not given where there are less than 20 isolates.

Trueperella pyogenes isolates from cases of bovine mastitis are reported in **Table 15**.

Table 17: Sheep, all ages, Respiratory Pathogens and *Trueperella pyogenes*

	Pasteurella multocida			*Mannheimia haemolytica*			*Bibersteinia trehalosi*			*Trueperella Pyogenes*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available/ % multi-resistant	12	2	5	63 / 0%	33 / 0%	20 / 0%	33 / 0%	30 / 0%	18	12	14	5
Amoxicillin / Clavulanic acid	0/12	0/2	0/5	0/63 0%	0/33 0%	0/20 0%	0/33 0%	0/30 0%	0/18	0/12	0/14	0/5
Ampicillin	0/12	0/2	0/5	0/63 0%	0/33 0%	0/20 0%	0/33 0%	0/30 0%	0/18	0/12	0/14	0/5
Cefalexin	-	-	-	0/2	-	-	-	-	-	0/12	0/14	0/5
Cefpodoxime	0/12	0/2	0/5	0/63 0%	0/33 0%	0/20 0%	0/33 0%	0/30 0%	0/18	-	-	-
Enrofloxacin	0/12	0/2	0/5	0/63 0%	0/33 0%	0/20 0%	0/33 0%	0/30 0%	0/18	-	-	-
Florfenicol	0/12	0/2	0/5	0/60 0%	0/33 0%	0/19	0/33 0%	0/30 0%	0/18	0/10	0/13	0/5
Tetracycline	2/12	0/2	1/5	0/63	0/33	0/20	1/33	2/30	1/18	6/12	1/14	2/5

				0%	0%	0%	3%	7%				
Trimethoprim / Sulphonamide	0/12	0/2	0/5	0/63 0%	0/33 0%	0/20 0%	0/33 0%	0/30 0%	0/18	5/10	7/13	0/5
Tylosin	-	-	-	0/2	-	-	-	-	-	1/12	0/14	0/5

Note: The percentage resistant is not given where there are less than 20 isolates.

Table 18: Pigs, all ages, Respiratory Pathogens and *Trueperella pyogenes*

	Pasteurella multocida			*Actinobacillus pleuropneumoniae*			*Trueperella pyogenes*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / % multi-resistant	63 / 2%	40 / 3%	39 / 5%	23 / 9%	22 / 50%	17	4	5	2
Amoxicillin / Clavulanic acid	0/37 0%	0/31 0%	0/24 0%	0/14	0/17	0/15	-	-	-
Ampicillin	0/60 0%	2/40 5%	3/39 8%	0/23 0%	3/22 14%	3/17	0/4	0/5	0/2
Apramycin	2/60 3%	1/40 3%	4/39 10%	8/23 35%	12/22 55%	8/17	-	-	-
Cefpodoxime	0/60 0%	0/40 0%	0/39 0%	0/23 0%	0/22 0%	0/17	-	-	-
Doxycycline	1/37 3%	1/31 3%	1/24 4%	0/14	0/17	1/15	-	-	-
Enrofloxacin	0/60 0%	0/40 0%	0/39 0%	0/23 0%	0/22 0%	0/17	0/4	0/5	0/2
Florfenicol	0/37	0/31	0/24	0/14	0/17	0/15	-	-	-

	0%	0%	0%						
Lincomycin	-	-	-	-	-	-	0/4	1/5	1/2
Neomycin	6/60 10%	0/40 0%	4/39 10%	8/23 35%	16/22 73%	7/17	-	-	-
Spectinomycin	0/60 0%	0/40 0%	1/39 3%	7/23 30%	12/22 55%	6/17	-	-	-
Streptomycin	5/37 14%	1/31 3%	3/24 13%	11/14	12/17	5/15	-	-	-
Tetracycline	52/60 87%	27/40 68%	33/39 85%	5/23 22%	7/22 32%	6/17	2/4	0/5	0/2
Trimethoprim / Sulphonamide	9/60 15%	7/40 18%	9/39 23%	0/23 0%	4/22 18%	5/17	4/4	1/5	1/2
Tylosin	5/37 14%	2/31 6%	4/24 17%	0/14	9/17	8/15	0/4	2/5	1/2

Note: The percentage resistant is not given where there are less than 20 isolates.

Table 19: Various species, *Erysipelothrix rhusiopathiae*

	Pigs			Sheep			Other Species*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available/ number multi-resistant	5/0	5/0	11/0	-	1/0	-	11/0	4/0	8/1
Amoxicillin / Clavulanic acid	-	-	-	-	0/1	-	0/5	0/3	0/4
Ampicillin	0/5	0/5	0/11	-	0/1	-	0/11	0/4	0/8
Enrofloxacin	0/5	0/5	0/11	-	-	-	0/11	0/4	1/8
Lincomycin	0/5	0/5	0/11	-	-	-	1/11	0/4	0/8
Tetracycline	1/5	1/5	4/11	-	0/1	-	2/11	1/4	4/8
Trimethoprim / Sulphonamide	2/5	4/5	8/11	-	1/1	-	4/11	2/4	4/8
Tylosin	0/5	0/5	0/11	-	0/1	-	1/11	0/4	1/8

Note: The percentage resistant is not given where there are less than 20 isolates.

* 2011 – isolates from chickens (3), pheasants (1) and turkeys (7).

* 2012 – isolates from chickens (1) and turkeys (3).

* 2013 – isolates from chickens (5) and turkeys (3).

Table 20: Zoonotic *Listeria*

	Cattle *Listeria monocytogenes*			Sheep *Listeria monocytogenes*			Sheep *Listeria ivanovii*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / number multi-resistant	6/0	3/0	4/0	16/0	16/0	10/0	2/0	2/0	2/0
Amoxicillin / Clavulanic acid	0/6	0/3	0/4	0/16	0/16	0/10	0/2	0/2	0/2
Ampicillin	0/6	0/3	0/4	0/16	0/16	0/10	0/2	0/2	0/2
Cefalexin	6/6	2/3	0/4	16/16	15/16	3/10	2/2	0/2	0/2
Florfenicol	0/2	0/2	0/4	0/16	0/15	0/10	0/2	0/2	0/2
Tetracycline	0/6	0/3	0/4	0/16	1/16	0/10	0/2	0/2	0/2
Trimethoprim / Sulphonamide	0/2	0/2	0/4	0/16	0/15	0/10	0/2	0/2	0/2
Tylosin	0/6	0/3	0/4	0/16	0/16	0/10	0/2	0/2	0/2

Note: The percentage resistant is not given where there are less than 20 isolates.

Table 21: Veterinary Streptococci

	Pigs - *Streptococcus suis*			Horses & Donkeys - *Streptococcus equi zooepidemicus*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / number multi-resistant	67/10	58/2	55/4	1/0	-	-
Ampicillin	0/67 0%	0/58 0%	0/55 0%	0/1	-	-
Penicillin	1/67 1%	1/58 2%	1/55 2%	0/1	-	-
Cefalexin	-	-	-	0/1	-	-
Enrofloxacin	0/67 0%	0/58 0%	0/55 0%	-	-	-
Lincomycin	35/67 52%	20/58 34%	25/55 45%	-	-	-
Tetracycline	66/67 99%	54/58 93%	52/55 95%	1/1	-	-
Trimethoprim / Sulphonamide	12/67 18%	9/58 16%	7/55 13%	0/1	-	-
Tylosin	39/67	26/58	26/55	0/1	-	-

	58%	45%	47%

Table 22: Avian species, all ages, *Klebsiella pneumoniae*

	2011	2012	2013
Total available / number multi-resistant	2/2	-	1/0
Ampicillin	2/2	-	1/1
Apramycin	0/2	-	0/1
Cefpodoxime	0/2	-	0/1
Doxycycline	0/2	-	0/1
Enrofloxacin	0/2	-	0/1
Spectinomycin	1/2	-	0/1
Tetracycline	1/2	-	0/1
Trimethoprim / Sulphonamide	2/2	-	0/1

Note: The percentage resistant is not given where there are less than 20 isolates.

* 2011 – isolates from a swift and a pheasant.

* 2013 – isolate from an unspecified avian species.

Table 23: *Yersinia* spp.

	Sheep			Avian species*			Cattle and Sheep		
	Yersinia pseudotuberculosis			*Yersinia pseudotuberculosis*			*Yersinia enterocolitica*		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Total available / number multi-resistant	2/0	-	1/0	-	-	-	-	-	-
Amoxicillin / Clavulanic acid	0/2	-	0/1	-	-	-	-	-	-
Ampicillin	0/2	-	0/1	-	-	-	-	-	-
Apramycin	-	-	0/1	-	-	-	-	-	-
Cefpodoxime	0/2	-	-	-	-	-	-	-	-
Doxycycline	-	-	-	-	-	-	-	-	-
Enrofloxacin	0/2	-	0/1	-	-	-	-	-	-
Neomycin	-	-	0/1	-	-	-	-	-	-
Spectinomycin	-	-	0/1	-	-	-	-	-	-
Tetracycline	0/2	-	0/1	-	-	-	-	-	-
Trimethoprim / Sulphonamide	0/2	-	0/1	-	-	-	-	-	-

Table 24: Sheep, all ages, *Corynebacterium pseudotuberculosis* and *Streptococcus dysgalactiae*

	Corynebacterium pseudotuberculosis			*Streptococcus dysgalactiae*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / number multi-resistant	10/0	5/0	4/0	28/0	23/0	26/0
Amoxicillin / Clavulanic acid	0/10	0/5	0/4	0/28 0%	0/23 0%	0/26 0%
Ampicillin	0/10	0/5	0/4	0/28 0%	0/23 0%	0/26 0%
Cefalexin	0/10	0/5	0/4	0/28 0%	0/23 0%	0/26 0%
Florfenicol	0/8	0/4	0/4	0/12	0/12	0/11
Tetracycline	1/10	1/5	0/4	28/28 100%	21/23 91%	22/26 85%
Trimethoprim / Sulphonamide	0/8	1/4	0/4	0/12	0/12	0/11
Tylosin	0/10	0/5	0/4	1/28 4%	1/23 4%	1/26 4%

Note: The percentage resistant is not given where there are less than 20 isolates.

Table 25: Chickens, Turkeys and Other Avian Species, all ages, *Staphylococcus aureus*

	Chickens			Turkeys			Other Avian Species*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / number multi-resistant	38/0	29/0	26/0	1/0	-	1/1**	3/1	-	3/2
Amoxicillin / Clavulanic acid	0/37 0%	0/23 0%	0/25 0%	0/1	-	1/1	0/1	-	0/2
Ampicillin	0/38 0%	4/29 14%	0/26 0%	0/1	-	1/1	0/3	-	1/3
Doxycycline	2/38 5%	1/29 3%	3/26 12%	0/1	-	0/1	1/3	-	2/3
Enrofloxacin	0/38 0%	0/29 0%	1/26 4%	0/1	-	0/1	0/3	-	0/3
Erythromycin	0/38 0%	0/25 0%	2/25 8%	0/1	-	0/1	1/1	-	2/2
Lincomycin	5/38 13%	6/29 21%	2/26 8%	0/1	-	0/1	1/3	-	2/3
Tetracycline	4/38 11%	2/29 7%	3/26 12%	0/1	-	1/1	1/3	-	2/3

Trimethoprim / Sulphonamide	0/38 0%	0/29 0%	0/26 0%	0/1	-	0/1	0/3	-	0/3
Tylosin	0/38 0%	0/29 0%	1/26 4%	0/1	-	0/1	1/3	-	2/3

Note: The percentage resistant is not given where there are less than 20 isolates.

* 2011 – pheasant (1), duck (1), grouse (1).

* 2013 – pheasant (2), unspecified avian species (1).

** This isolate was methicillin-resistant *S. aureus* (MRSA) multi-locus sequence type 398.

Table 26: Cattle, Chickens and Other Species, *Staphylococcus xylosus*

	Cattle			Chickens			Other Species*		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Total available / number multi-resistant	1/0	-	-	1/0	3/1	3/3	1/1	-	-
Amoxicillin / Clavulanic acid	0/1	-	-	0/1	0/3	0/3	0/1	-	-
Ampicillin	0/1	-	-	0/1	0/3	1/3	0/1	-	-
Cefalexin	0/1	-	-	-	-	-	-	-	-
Doxycycline	-	-	-	1/1	2/3	2/3	1/1	-	-
Enrofloxacin	-	-	-	0/1	0/3	0/3	0/1	-	-
Erythromycin	-	-	-	0/1	1/3	2/3	0/1	-	-
Lincomycin	-	-	-	1/1	2/3	3/3	1/1	-	-
Neomycin	0/1	-	-	-	-	-	-	-	-
Tetracycline	0/1	-	-	1/1	2/3	2/3	1/1	-	-
Trimethoprim / Sulphonamide	-	-	-	0/1	0/3	0/3	0/1	-	-
Tylosin	0/1	-	-	0/1	0/3	1/3	0/1	-	-

* 2011 - turkey.

Table 27: All Salmonellas: antibiotic sensitivity 2013

Origin	No of cultures	Percentage sensitive to all 16 antimicrobials	Na	Cip	S	N	Apr	Cn	Su	Tm	Am	Amc	Caz	Ctx	Fr	T	C
Cattle	518	90.7	1.4	0	6.2	0.2	0	0.2	5.4	0.8	5.0	0	0	0	0	6.2	1.0
Sheep	91	94.5	0	0	2.2	0	0	1.1	2.2	0	2.2	0	0	0	0	2.2	0
Pigs	178	12.9	1.7	0	74.7	2.8	7.9	8.4	84.3	55.6	74.7	5.6	0.6	0.6	0	79.2	28.1
Chickens	850	64.2	8.0	1.4	10.9	2.8	2.4	3.5	21.8	10.9	7.4	0	0	0	2.8	20.9	3.9
Turkeys	242	14.9	20.2	7.0	67.8	0.4	0	0.4	60.3	10.7	31.0	0	0	0	0.8	56.6	0.4
Ducks	191	67.5	2.1	0	25.1	22.5	0	0	7.9	4.2	4.7	0	0	0	23.0	23.6	0.5
Geese	1	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Horses	54	57.4	0	0	37.0	0	0	0	38.9	1.9	35.2	0	0	0	0	38.9	3.7
Dogs	50	46.0	6.0	4.0	32.0	0	0	4.0	42.0	4.0	42.0	0	0	0	0	38.0	2.0
Other non-avian species	285	72.3	1.1	0	5.6	1.1	0.4	0.7	22.1	18.2	4.9	0	0	0	0.4	24.9	0.7
Other avian species	48	58.3	14.6	6.3	18.8	2.1	2.1	2.1	14.6	2.1	14.6	0	0	0	0	27.1	4.2
Feed	28	92.9	0	0	0	0	0	0	7.1	7.1	0	0	0	0	0	7.1	0
Environment	350	70.9	0	0	2.6	1.1	0	0.3	21.7	19.1	3.7	0	0	0	0	26.3	0.3
Total	2886	64.2	5.0	1.2	18.8	2.8	1.2	1.9	24.8	12.4	13.2	0.3	0.03	0.03	2.5	26.1	3.4

Note: The antibiotic codes e.g. S are provided at Annex 1. Most of the cattle isolates are clinical and those from pigs and poultry a mixture of clinical and non-clinical. *[No isolates were resistant to amikacin in 2013]*

Table 28: *Salmonella* Dublin: antibiotic sensitivity monitoring 2004-2013

Year	No. of isolates	Percentage sensitive to all 16 antibiotics	Percentage of isolates resistant to:								
			S	C	SU	T	N	AM	FR	TM	NA
2004	516	97.9	1.0	0.8	1.2	0.4	0	0.2	0	0.8	0.2
2005	365	98.1	1.1	0.3	0.3	0.3	0	0.8	0	0	0
2006	468	96.4	0.4	0.6	1.3	0.6	0.2	0.9	0	0.2	1.5
2007	381	98.7	0.8	0	0	0.2	0	0.2	0	0	0
2008	404	96.0	3.2	0.3	0.3	0.5	0	0.3	0.3	0	0.3
2009	560	92.3	7.0	0.4	0.5	0.9	0	0.5	0.2	0	0.4
2010	630	95.7	2.7	0.2	0.5	0	0	0.2	0	0	1.3
2011	453	96.0	3.3	0.4	0.4	0.4	0	0.2	0	0	0.4
2012	327	97.2	1.8	0.3	0	0.3	0	0.6	0	0	0.6
2013	393	96.9	1.3	0	0	0	0.3	0.3	0	0	1.0

Note: The antibiotic codes e.g. S are provided at **Annex 6**.

Figure 29: Percentage of the eight most common definitive and undefined types of *Salmonella* Typhimurium sensitive to 16 antibiotics in 2013

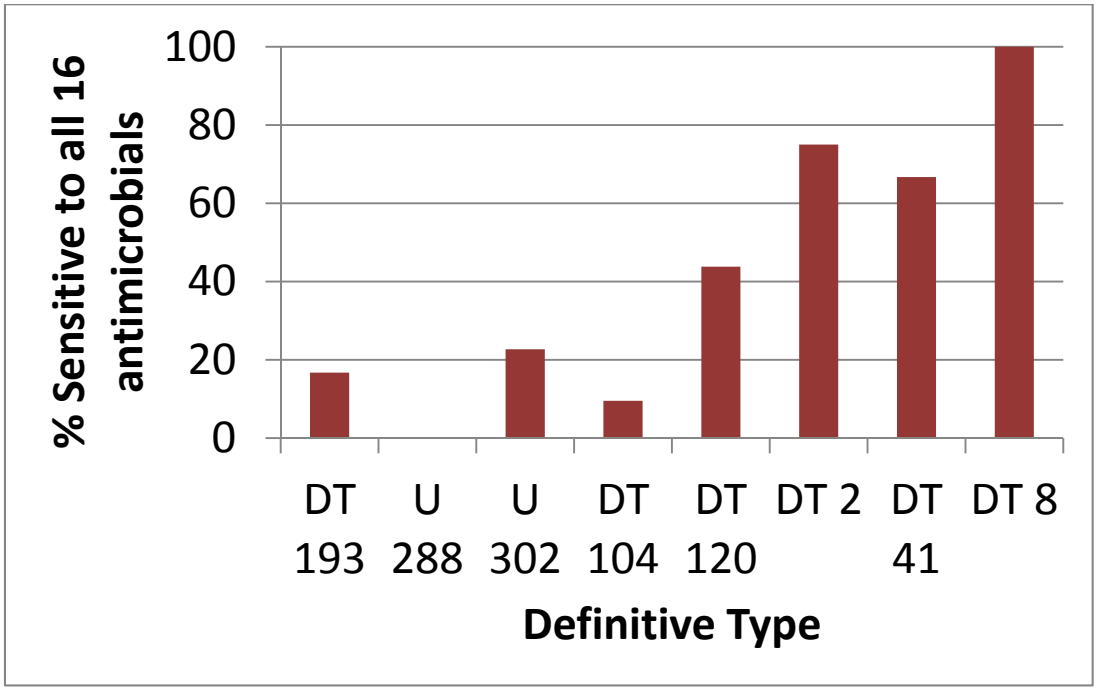

Table 29: *Salmonella* Typhimurium: antibiotic sensitivity monitoring 2004-2013

Year	No. of isolates (DT104)*	Percentage sensitive to all 16 Antibiotics	Percentage of isolates resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
2004	468 (126)	26.7	55.8	63.7	65.6	4.5	58.5	0.6	32.7	49.4	1.5	10.0
2005	552 (144)	24.1	60.0	71.6	71.0	1.3	67.2	4.2	36.1	53.1	0.7	8.9
2006	1136 (316)	24.2	54.2	70.2	69.2	5.1	65.9	1.0	39.8	57.0	1.0	6.9
2007	1057 (181)	11.4	70.6	85.3	81.6	4.5	78.4	0.6	57.9	58.8	1.5	4.5
2008	709 (171)	19.6	65.7	70.7	73.8	1.6	66.2	-	26.4	43.0	1.0	3.5
2009	440 (64)	25.7	60.7	67.5	65.7	3.0	61.1	0.2	40.7	46.1	1.1	4.1
2010	328 (45)	33.5	54.6	56.7	58.2	3.0	51.2	0.3	27.1	36.3	4.0	5.2
2011	427 (52)	34.4	51.3	56.2	57.4	3.5	49.2	-	37.5	24.6	20.4	4.9
2012	191 (35)	27.2	59.1	63.9	64.9	2.1	56.5	0.5	41.9	30.4	20.4	2.6
2013	165 (47)	30.3	54.5	60.6	61.2	0.6	57.6	-	44.8	35.2	1.8	4.8

Note: The antibiotic codes e.g. S are provided at **Annex 6**.
* Includes the variants of DTI04, DT104B and U302.

Table 30: Nalidixic acid resistance in *Salmonella* Typhimurium DT104 from domestic livestock 2004-2013. Number of isolates tested (percentage resistant to nalidixic acid)

	Livestock species					
Year	**Turkeys**	**Chickens**	**Ducks**	**Cattle**	**Pigs**	**Sheep**
2004	39(74.4)	6(0)	0(0)	44(0)	10(10.0)	2(0)
2005	32(96.9)	6(33.3)	0(0)	40(12.5)	2(0)	8(0)
2006	57(71.9)	6(50)	0(0)	112(0)	20(0)	12(0)
2007	11(100)	5(0)	0(0)	33(3)	22(0)	7(0)
2008	0(0)	6(0)	0(0)	29(3.4)	34(0)	5(0)
2009	0(0)	2(0)	0(0)	25(8)	13(15.4)	1(0)
2010	2(100)	5(0)	0(0)	19(0)	3(0)	2(0)
2011	2(100)	1(0)	0(0)	16(18.8)	0(0)	1(0)
2012	0(0)	0(0)	0(0)	6(0)	5(0)	2(0)
2013	0(0)	8(0)	0(0)	9(33.3)	1(0)	0(0)

Table 31: Trimethoprim/sulphonamide resistance in *Salmonella* Typhimurium (all phage types) from domestic livestock in 2004-2013. Number of isolates tested (percentage resistant to trimethoprim/sulphonamide)

	Livestock species					
Year	**Turkeys**	**Chickens**	**Ducks**	**Cattle**	**Pigs**	**Sheep**
2004	55(2)	11(0)	7(0)	90(30)	147(72)	7(57)
2005	37(3)	10(20)	13(0)	71(14)	317(56)	13(31)
2006	86(7)	13(15)	35(14)	174(20)	555(69)	18(28)
2007	24(0)	10(0)	3(0)	86(5)	792(75)	10(0)
2008	20(0)	39(0)	8(0)	76(0)	404(42)	6(0)
2009	1(0)	41(7)	11(0)	70(0)	237(70)	4(0)
2010	5(40)	25(4)	44(9)	63(5)	108(67)	5(20)
2011	6(0)	20(10)	40(2.5)	39(15)	244(61)	1(0)
2012	0(0)	9(22)	4(0)	15(7)	99(73)	5(0)
2013	0(0)	12(8)	3(0)	24(13)	71(93)	0(0)

Table 32: Trimethoprim/sulphonamide resistance in *Salmonella* Typhimurium DT104 from domestic livestock in 2004-2013. Number of isolates tested (percentage resistant to trimethoprim/sulphonamide)

	Livestock species					
Year	**Turkeys**	**Chickens**	**Ducks**	**Cattle**	**Pigs**	**Sheep**
2004	39(0)	6(0)	0(0)	44(34)	10(10)	2(50)
2005	32(0)	6(33.3)	0(0)	40(17.5)	2(0)	8(37.5)
2006	57(8.8)	6(16.7)	0(0)	112(22.3)	20(15)	12(41.7)
2007	11(0)	5(0)	0(0)	33(0)	22(4.5)	7(0)
2008	0(0)	6(0)	0(0)	29(0)	34(5.9)	5(0)
2009	0(0)	2(0)	0(0)	25(0)	13(30.8)	1(0)
2010	2(0)	5(0)	0(0)	19(0)	3(0)	2(0)
2011	2(0)	1(0)	0(0)	16(12.5)	0(0)	1(0)
2012	0(0)	0(0)	0(0)	6(0)	5(60)	2(0)
2013	0(0)	8(12.5)	0(0)	9(0)	1(0)	0(0)

Table 33: Trends in Trimethoprim/sulphonamide resistance in certain phage types of *Salmonella* Typhimurium from pigs over the period 2004-2013. Number of isolates tested (percentage resistant to trimethoprim/sulphonamide)

	Determinative type or undefined type		
Year	**DT 193**	**DT 208**	**U288**
2004	19 (79)	1 (100)	71 (97)
2005	134 (43)	0 (0)	107 (96)
2006	103 (72)	16 (25)	229 (96)
2007	239 (65)	7 (14)	374 (97)
2008	153 (35)	28 (29)	106 (95)
2009	71 (69)	2 (50)	100 (98)
2010	35 (57)	1 (0)	38 (90)
2011	39 (46)	1 (0)	55 (96)
2012	24 (63)	0 (0)	34 (94)
2013	22(91)	0(0)	21(100)

Table 34: Salmonellas, other than *Salmonella* Dublin and *Salmonella* Typhimurium; antibiotic sensitivity monitoring 2004-2013

Year	No. of isolates	% sensitive to all 16 antibiotics	Percentage of isolates resistant to:									
			S	SU	T	N	AM	FR	TM	C	APR	NA
2004	2942	67.3	11.6	19.1	17.5	7.2	2.2	7.8	14.0	1.3	0.3	2.1
2005	2683	65.6	10.9	23.7	23.6	4.2	4.6	6.2	12.3	2.5	0.1	2.2
2006	2727	58.7	15.8	25.1	28.8	6.9	7.2	5.7	14.2	3.2	0.2	4.0
2007	2248	63.4	12.8	22.2	28.8	4.0	7.7	3.5	11.9	2.2	0.2	3.4
2008	2474	67.3	14.0	17.5	23.7	3.2	5.0	1.3	8.1	1.8	0.3	1.8
2009	1990	64.0	16.4	23.2	24.4	4.1	8.1	2.9	12.6	2.5	1.7	2.1
2010	2126	56.7	29.1	35.7	32.5	3.4	12.9	0.8	11.2	1.3	0.7	1.8
2011	1982	56.4	27.2	35.1	31.1	2.7	16.3	0.2	13.6	3.6	3.2	2.6
2012	2018	75.0	25.0	33.1	33.4	3.6	13.9	1.5	12.2	1.7	2.0	4.0
2013	2328	61.2	19.2	26.5	28.0	3.4	12.3	3.1	12.2	1.7	1.4	5.7

Note: The antibiotic codes e.g. S are provided at Annex 1.

Table 35: *Salmonella* spp. from the Broiler *Salmonella* National Control Programme (n=170) in 2013. MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotics	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																	
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024
Tetracyclines	23									119	9	3	*	3	36				
Chloramphenicol	3											145	20*	4	1				
Ampicillin	11								122	21	8	2	1*	16					
Cefotaxime	0						167	3			*								
Nalidixic acid	4										150	13		*	7				
Ciprofloxacin	4		68	85	10		4		3	*									
Sulphonamide	19											9	122	5		1			33
Trimethoprim	18							135	3	2	*			30					
Streptomycin	6										7	23	12*	2	2	1			
Gentamicin	5							143	19			1*	4	3					

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 36: *Salmonella* spp. from the Laying Hen *Salmonella* National Control Programme (n=56), 2013. MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																	
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024
Tetracyclines	14								10	38			*		8				
Chloramphenicol	0									2	12	42	*						
Ampicillin	13							1	33	12	3		*	7					
Cefotaxime	0				37	16	2	1			*								
Nalidixic acid	0										55	1		*					
Ciprofloxacin	0	1	25	28	2					*									
Sulphonamide	13											13	33	3					7
Trimethoprim	2							54	1		*			1					
Streptomycin	13										11	25	11*	2		7			
Gentamicin	0						15	36	4	1		*							

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 37: *Salmonella* spp. from the Turkey *Salmonella* National Control Programme (n=170), 2013. MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024
Tetracyclines	69								5	43	5		3*		114				
Chloramphenicol	0									2	14	127	27*						
Ampicillin	26							2	97	26	1		1*	43					
Cefotaxime	0				43	93	26	8			*								
Nalidixic acid	14										143	3		*	24				
Ciprofloxacin	14	2	37	104	3		6	17	1	*									
Sulphonamide	70											4	41	5	1				119
Trimethoprim	13							141	7		*			22					
Streptomycin	69									1	11	27	11*	2	3	115			
Gentamicin	0						45	118	7			*							

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 38: *Salmonella* spp. from Pigs at Slaughter (n=147), 2013. MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024
Tetracyclines	68								13	34			*	3	97				
Chloramphenicol	24									1	10	95	5*		36				
Ampicillin	52								49	21			*	77					
Cefotaxime	0				92	45	10				*								
Nalidixic acid	0.7										138	6	2	*	1				
Ciprofloxacin	2		47	97		2	1			*									
Sulphonamide	63											1	39	15					92
Trimethoprim	29							103		1	*			43					
Streptomycin	55									1	9	40	13*	3	2	79			
Gentamicin	16						23	93	7			1*	15	8					

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 39: *Campylobacter jejuni* from Broilers (n=61). Distribution of MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512
Tetracyclines	48						22	10			*		29					
Ciprofloxacin	31				10	21	10	1	*		19							
Nalidixic acid	31									5	28	9			19			
Streptomycin	0								60	1								
Gentamicin	0					32	28	1										
Erythromycin	0							28	24	7	2	*						

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 40: *Campylobacter coli* from broilers (n=33). Distribution of MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)															
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512
Tetracyclines	55						12	3			*		18					
Ciprofloxacin	42				9	8	1	1	*		14							
Nalidixic acid	42									2	12	4	1		14			
Streptomycin	15								27	1			5					
Gentamicin	0					13	18	2										
Erythromycin	3							19	8	4	1	*		1				

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.
Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.
ECV – Epidemiological cut-off value.
* - Clinical break-point

Table 41: *Campylobacter coli* from pigs (n=141). Distribution of MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512
Tetracyclines	79						2	17	10		5*	7	100					
Ciprofloxacin	13				19	48	53	2	1*	1	17							
Nalidixic acid	16									1	23	67	28	3	19			
Streptomycin	71								21	20	6	7	87					
Gentamicin	0					18	73	45	5									
Erythromycin	28							10	22	46	24	1*		38				

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Table 42: *E. coli* from Pigs at Slaughter (n=157), 2013. MIC values for selected antibiotics, determined in accordance with EFSA's recommendations

Antibiotic	Percentage above ECV	Number of isolates with a minimum concentration of inhibition equal to: (MIC in mg/L)																
		0.008	0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024
Tetracyclines	67								23	28	1		*	2	103				
Chloramphenicol	22									8	45	69	1*	17	17				
Ampicillin	31								8	48	52	2	*	47					
Cefotaxime	0.6				144	11	1				1*								
Nalidixic acid	1										154	1		*	2				
Ciprofloxacin	1	24	115	15	1	1				*		1							
Sulphonamide	52											56	18	2					81
Trimethoprim	41							88	4		*			65					
Streptomycin	37										37	27	16*	19	23	35			
Gentamicin	3						16	115	22			3*		1					
Colistin	0									157									

Red shading denotes the dilution range tested. Isolates at the highest end of a concentration range may have an MIC equal to or higher than that concentration.

Bold vertical lines indicate the epidemiological cut-off values recommended by EFSA.

ECV – Epidemiological cut-off value.

* - Clinical break-point

Annex 6 - Disc diffusion breakpoints, corresponding MIC breakpoints and breakpoints under review for the main bacteria covered in this report

Table 43: Disc diffusion breakpoints, corresponding MIC breakpoints and breakpoints under review for the main bacteria covered in this report

Antibiotic	**Disc Charge (micrograms)**	***Escherichia coli*, Enterobacteriaceae**	***Salmonella***	***Staphylococci***	***Streptococci***	***Pasteurella, Mannheimia, Histophilus, Actinobacillus***
Amikacin (AK)	30	R ≤ 18mm R ≥ 16mg/l	R ≤ 18mm R ≥ 16mg/l	NA	NA	NA
Amoxicillin/ clavulanic acid (AMC)	20/10	R ≤ 14mm R>8mg/l	R ≤ 14mm R>8mg/l	NA	NA	R ≤ 13mm
Amoxicillin/ clavulanic acid	2/1	NA	NA	R ≤ 17mm R>1mg/l	R ≤ 13mm	NA
Ampicillin (AM)	10	R ≤ 14mm R>8mg/l	R ≤ 14mm R>8mg/l	R ≤ 13mm	R ≤ 13mm	R ≤ 29mm R>1mg/l
Apramycin (APR)	15	R ≤ 13mm R ≥ 32 mg/l	R ≤ 13mm R ≥ 32 mg/l	NA	NA	R ≤ 13mm[†]
Cefotaxime (CTX)	30	R ≤ 29mm R≥2mg/l	R ≤ 29mm R≥2mg/l	NA	NA	NA
Cefpodoxime	10	R ≤ 19mm	NA	NA	NA	R ≤ 13mm

Antibiotic	**Disc Charge (micrograms)**	***Escherichia coli,* Enterobacteriaceae**	***Salmonella***	***Staphylococci***	***Streptococci***	***Pasteurella, Mannheimia, Histophilus, Actinobacillus***
		R>1mg/l				
Ceftazidime (CAZ)	30	R ≤ 26mm R ≥ 2mg/l	R ≤ 26mm R ≥ 2mg/l	NA	NA	NA
Cefalexin	30	R ≤ 15mm R>16mg/l	NA	R ≤ 13mm	R ≤ 24mm R>2mg/l	R ≤ 13mm
Chloramphenicol (C)	30	R ≤ 20mm R>8mg/l	R ≤ 20mm R>8mg/l	NA	NA	NA
Ciprofloxacin (CIP)	1	NA	R ≤ 16mm R≥1mg/l	NA	NA	NA
Doxycycline	30	R ≤ 13mm	NA	R ≤ 30mm R≥2mg/l	NA	R ≤ 13mm
Erythromycin	5	NA	NA	R ≤ 19mm R≥2mg/l	R ≤ 21mm* R ≥ 0.5mg/l	R ≤ 13mm
Enrofloxacin	5	R ≤ 13mm R ≥ 4mg/l	NA	R ≤ 13mm	R ≤ 13mm	R ≤ 13mm
Florfenicol	30	R ≤ 13mm	NA	NA	R ≤ 13mm	R ≤ 13mm

Antibiotic	**Disc Charge (micrograms)**	***Escherichia coli,* Enterobacteriaceae**	***Salmonella***	***Staphylococci***	***Streptococci***	***Pasteurella, Mannheimia, Histophilus, Actinobacillus***
		R > 32mg/l				
Furazolidone (FR)	15	NA	≤13mm	NA	NA	NA
Gentamicin (CN)	10	NA	R ≤ 19mm R≥4mg/l	NA	NA	NA
Lincomycin	10	NA	NA	R ≤ 13mm	R ≤ 13mm	R ≤ 13mm
Nalidixic acid (NA)	NA	NA	≤ 13mm	NA	NA	NA
Neomycin (N)	10	R ≤ 13mm R > 8mg/l	R ≤ 13mm R > 8mg/l	NA	NA	NA
Neomycin	30	NA	NA	R ≤ 13mm	R ≤ 13mm	NA
Novobiocin	30	NA	NA	R ≤ 13mm	R ≤ 13mm	NA
Penicillin	1IU	NA	NA	R ≤ 24mm R>0.12mg/l	R ≤ 19mm** R>0.25mg/l	R ≤ 21mm R > 0.12 mg/l
Spectinomycin	25	R ≤ 13mm	NA	NA	NA	R ≤ 13mm†
Streptomycin (S)	10	R ≤ 12mm R>8mg/l	R ≤ 13mm R> ~8mg/l	NA	NA	R ≤ 13mm†
Sulphonamide	300	NA	≤ 13mm	NA	NA	NA

Antibiotic	**Disc Charge (micrograms)**	***Escherichia coli,* Enterobacteriaceae**	***Salmonella***	***Staphylococci***	***Streptococci***	***Pasteurella, Mannheimia, Histophilus, Actinobacillus***
compounds (SU)						
Tetracycline (T)	10	R ≤ 13mm R > 8mg/l	R ≤ 13mm R>8mg/l	R ≤ 19mm R≥2mg/l	R ≤ 19mm*** R≥2mg/l	R ≤ 25mm
Trimethoprim/ sulphonamide (TM)	25	R ≤ 15mm R≥4mg/l	R ≤ 15mm R≥4mg/l	R ≤ 16mm R≥4mg/l	R ≤ 19mm R ≥ 2mg/l	R ≤ 13mm
Tylosin	30	NA	NA	R ≤ 13mm	R ≤ 13mm	R ≤ 13mm

Key:

BSAC breakpoint.

Animal and Plant Health Agency (APHA) historical veterinary disc diffusion zone size breakpoint and MIC corresponding to that zone size breakpoint, derived from studies of zone size and MIC.

APHA historical veterinary breakpoint (under ongoing review).

Notes

Where zone size disc diffusion data collected using the BSAC method and MIC data are both available then it is possible to draw regression lines and investigate the MIC which approximately corresponds to the historical veterinary breakpoint of 13mm. This has been done for several compounds (highlighted in blue in the table above).

BSAC state that all *Salmonella* isolates should be reported as resistant to gentamicin and amikacin; resistance traits are used for epidemiological purposes (correlation with particular resistance mechanisms) in this report.

* Erythromycin R $\leq$ 21mm for beta-haemolytic streptococci; R $\leq$ 19mm for other streptococci.

** Penicillin R $\leq$ 19mm for beta-haemolytic streptococci; R $\leq$ 16mm for other streptococci.

*** Tetracycline R $\leq$ 19mm for beta-haemolytic streptococci; R $\leq$ 23mm for other streptococci.

[†]Some Haemophilus Pasteurella Actinobacillus “HPA” organisms, for example *Actinobacillus pleuropneumoniae*, show a degree of intrinsic resistance to aminoglycosides.

The 16 antibiotics with antibiotic code e.g. amikacin (AK) are the set used for *Salmonella* susceptibility testing.

Annex 7 – Glossary of Terms

a.i.	Active Ingredient; the part of an antimicrobial medicine that acts against the bacterial infection.
Aminoglycosides	A closely related group of bactericidal antibiotics derived from bacteria of the order Actinomycetales. Polycationic compounds that contain an aminocyclitol with cyclic amino-sugars attached by glycoside linkages. Sulphate salts are generally used. They have broadly similar toxicological features.
Antibiotic	A term synonymous with anti-bacterials.
Antifungal	Products that are destructive to or suppress the reproduction or growth of fungi.
Antimicrobial	A general term for any compound with a direct action on micro-organisms used for treatment or prevention of infections. Antimicrobials are inclusive of anti-bacterials, anti-virals, anti-fungals and anti-protozoals.
Antimicrobial Resistance	The ability of a micro-organism to grow or survive in the presence of an antimicrobial that is usually sufficient to inhibit or kill micro-organisms of the same species.
Antiprotozoal	A drug primarily used in the treatment and/or prevention of parasitic protozoal infections.
β-Lactam	Semi-synthetic antibiotics derived from penicillin G or cephalosporin C, natural antibiotics produced by the mould *Cephalosporium acremonium*. Bactericidal products that act by inhibiting synthesis of the bacterial cell wall.
Coccidiostat	Product used for the prevention of coccidiosis, a protozoal infection causing diarrhoea and dysentery.
Critically Important Antibiotics	These are antibiotics which; are the sole or one of few available treatments for serious human disease; and are used to treat diseases caused by organisms that may be transmitted to humans from non-human sources or, human diseases caused by organisms that may acquire resistance genes from non-human sources, (WHO definition). They include the following classes of antibiotics; fluoroquinolones; 3rd and 4th generation cephalosporins; and macrolides.
Defra	Department for Environment, Food and Rural Affairs.
Eurostat	Eurostat is the statistical office of the European Union.
FAO	Food and Agriculture Organisation of the United Nations.
Fluoroquinolone	A sub-group of the quinolone compounds, having the addition of a fluorine atom and the 7-piperazinyl group. Broad-spectrum antibacterials

	with properties more suited to the treatment of systemic infections.
Food Animals	Animals used for food production including: cattle, sheep, pigs, poultry, salmon, trout and bees.
Growth Promoter	Substances, which, when given in animal feed, increase feed conversion efficiency or result in better daily live weight gain, or both.
Injectable Product	A product which is administered to animals via injection.
Intramammary Product	A product which is administered into the udder.
Ionophore	A small hydrophobic molecule that dissolves in lipid bilayer membranes and increases permeability to inorganic ions.
Macrolide	A large group of antibiotics mainly derived from *Streptomyces* spp. Weak bases that are only slightly soluble in water. They have low toxicity and similar antimicrobial activity with cross-resistance between individual members of the group. Thought to act by interfering with bacterial protein synthesis.
Medicated Feeding stuff	Feeding stuffs that contain a veterinary medicine and that are intended for feeding to animals without further processing.
Non-Food Animals	Animals not reared for food. These are mainly companion animals including, dogs, cats, horses, small mammals, rabbits and birds.
Non-Ionophore Coccidiostat	All coccidiostats with alternative modes of action to those shown by ionophores.
OIE	World Organisation for Animal Health.
Population Correction Unit (PCU)	This is a technical unit of measurement which is used to represent the estimated weight at treatment of livestock and slaughtered animals. 1 PCU = 1 kg of different categories of livestock and slaughtered animals.
Special Import Certificate (SIC)	A certificate issued by the VMD on behalf of the Secretary of State to permit veterinary surgeons to legally import veterinary medicinal products with current EU authorisations into the UK to treat animals under the 'cascade'.
Special Treatment Certificate (STC)	A certificate issued by the VMD on behalf of the Secretary of State to permit veterinary surgeons to legally import other products/substances, where the health situation demands and where there is no EU authorised treatment available.
Sulphonamide	A group of bacteriostatic compounds that interfere with folic acid synthesis of susceptible organisms. They all have similar antimicrobial activity but different pharmacokinetic properties.
Tetracycline	A group of antibiotics derived from *Streptomyces* spp. They are usually bacteriostatic at concentrations achieved in the body and act by

	interfering with protein synthesis in susceptible organisms. All have a broad spectrum of activity.
Therapeutic Product	A product which treats or prevents disease.
TRACES	European Commission's Director General Health and Consumer owned - The 'TRAde Control and Expert System' (TRACES) is a management tool for tracking the movements of animals, products of animal and non-animal origin and since version 6.00 also of plants, from both outside the European Union and within its territory.
Trimethoprim	Compounds with a similar action to sulphonamides, acting by interfering with folic acid synthesis, but at a different stage in the metabolic pathway. Display a similar spectrum of activity to, and are often used in combination with, sulphonamides.
VMD	Veterinary Medicines Directorate, an Executive Agency of the Department for Environment, Food and Rural Affairs (Defra).
Water/Oral Product	A product that is administered to animals orally. Includes tablets, boluses, capsules, dissolvable powders and sachets, solutions, etc.
WHO	World Health Organisation.

Annex 8 – Contributors

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