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UK Veterinary Antibiotic Resistance and Sales Surveillance Report

UK Veterinary Antibiotic Resistance and Sales Surveillance

Editor in Chief

Professor S. Peter Borriello

Veterinary Medicines Directorate
Woodham Lane
New Haw
Addlestone
Surrey, KT15 3LS

Authors

Veterinary Medicines Directorate

- Fraser Broadfoot
- Stacey Brown
- Katherine Grace
- Callum Harris
- Kitty Healey
- Hannah Reeves

Animal and Plant Health Agency

- Chris Teale

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Correspondence

Any correspondence relating to this report should be sent by email to:
postmaster@vmd.defra.gsi.gov.uk

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Executive Summary

Antibiotic sales

All figures calculated using the European agreed ESVAC method unless specified.

Overall trends in mg/kg (using population correction unit)

This year the methodology used to calculate national sales data trends for this report has been changed so it is harmonised and consistent with methodology used across European countries.

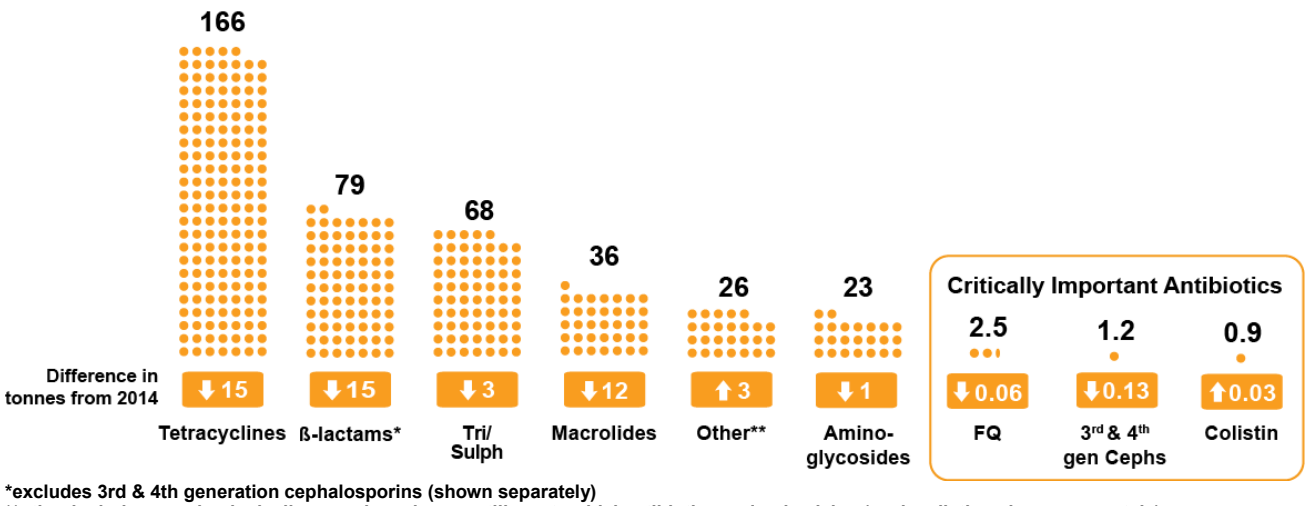
Between 2014 and 2015, antibiotics for use in food producing animals (in mg/PCU) decreased by 10% from 62 to 56 mg/PCU.

Sales of highest priority critically important antibiotics remain low and were little changed compared to 2014: sales of 3rd and 4th generation cephalosporins were 0.17mg/PCU in 2015 (compared to 0.19mg/PCU in 2014) and sales of fluoroquinolones were 0.34mg/PCU in 2015 (compared to 0.35 mg/PCU in 2014).

Colistin was included as a critically important antibiotic for the first time in this year's UK-VARSS report, following the discovery of the plasmid mediated resistance gene *mcr-1* in China in November 2015. Sales of colistin in the UK were 0.12mg/PCU, which is below the European Medicines Agency's Antimicrobial Expert Group's recommended target of 1mg/PCU.

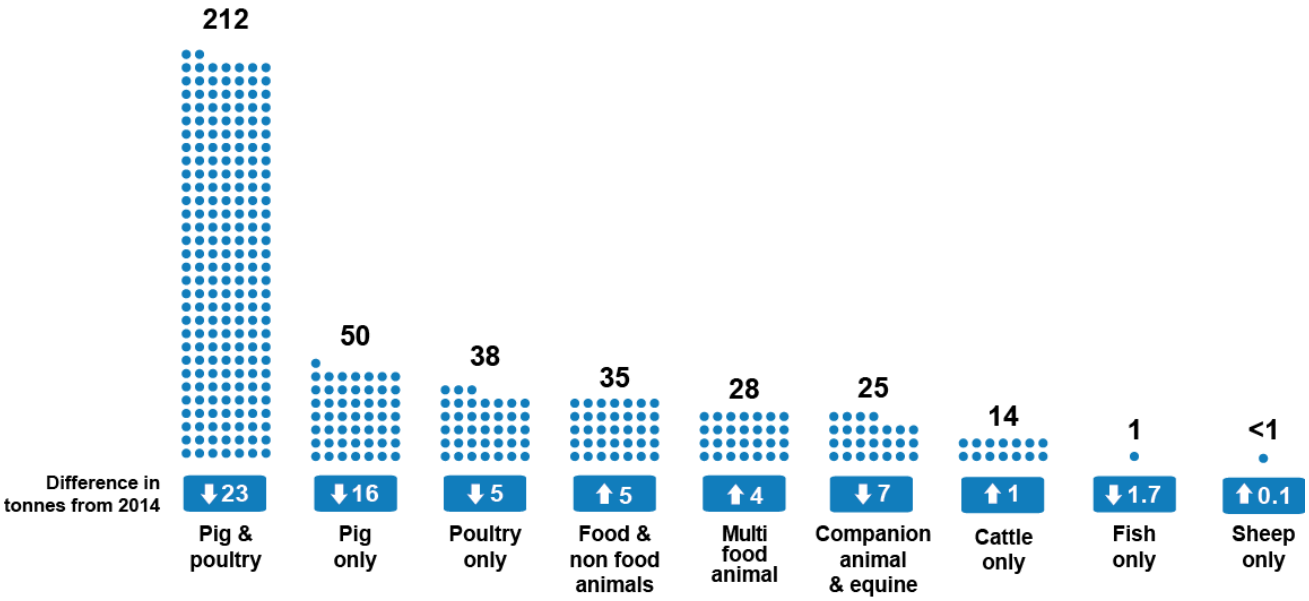
	2012	2013	2014	2015	Compared with 2014
Total in mg/PCU	66	62	62	56	⬇ 10%
Fluoroquinolones (FQ) in mg/PCU	0.33	0.36	0.35	0.34	⬇ 3%
3rd & 4th gen Cephalosporins in mg/PCU	0.20	0.18	0.19	0.17	⬇ 11%
Colistin in mg/PCU	0.09	0.11	0.12	0.12	—
Total sales in tonnes	464	436	445	404	⬇ 9%

Total sales in tonnes of active ingredient by class



*excludes 3rd & 4th generation cephalosporins (shown separately)
**other includes: amphenicols, lincomycins, pleuromutilins, steroidal antibiotics and polymixins (excl. colistin - shown separately)

Total sales in tonnes of active ingredient by species indicated



The mg/PCU for products only authorised for use in pigs and/or poultry decreased by 16% between 2014 and 2015, from 192 mg/PCU to 162 mg/PCU.

Antibiotic Usage and Data Collection Activities by Livestock Species

In order to optimise usage of antibiotics in livestock it is important to monitor antibiotic use in each species. The VMD has been working with the poultry, pig and cattle sectors to develop systems to monitor their antibiotic usage. Highlights include:

The British Poultry Council reported that use of antibiotics by members of its Antibiotic Stewardship Scheme in 2015 reduced by 27% compared to 2014, including a 52% reduction in the use of fluoroquinolones.

Agriculture and Horticulture Development Board pork reported that, by the end of October 2016, 534 sites had signed up to their online reporting system eMB-Pigs, covering 17% of national pig production (2,544,186 finishers, 2,988,379 weaners and 371,580 sows and boars).

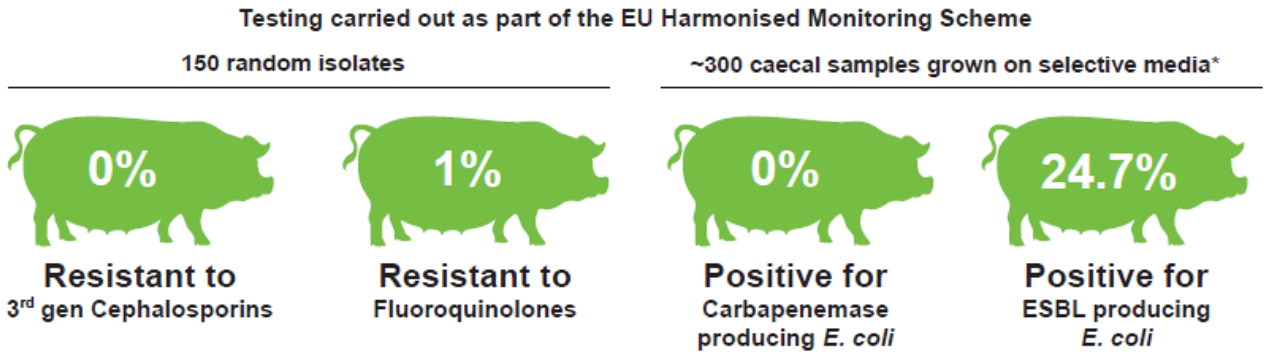
The Cattle Health and Welfare Group completed a scoping study to investigate current data recording systems and have developed a proposal for a data capture system, that should be operational by 2017.

Antibiotic Resistance

Percentage resistance in *E. coli* from randomly selected healthy pigs

In 2015, isolates of *E. coli* from the caeca of healthy pigs randomly selected at slaughter were tested for resistance.

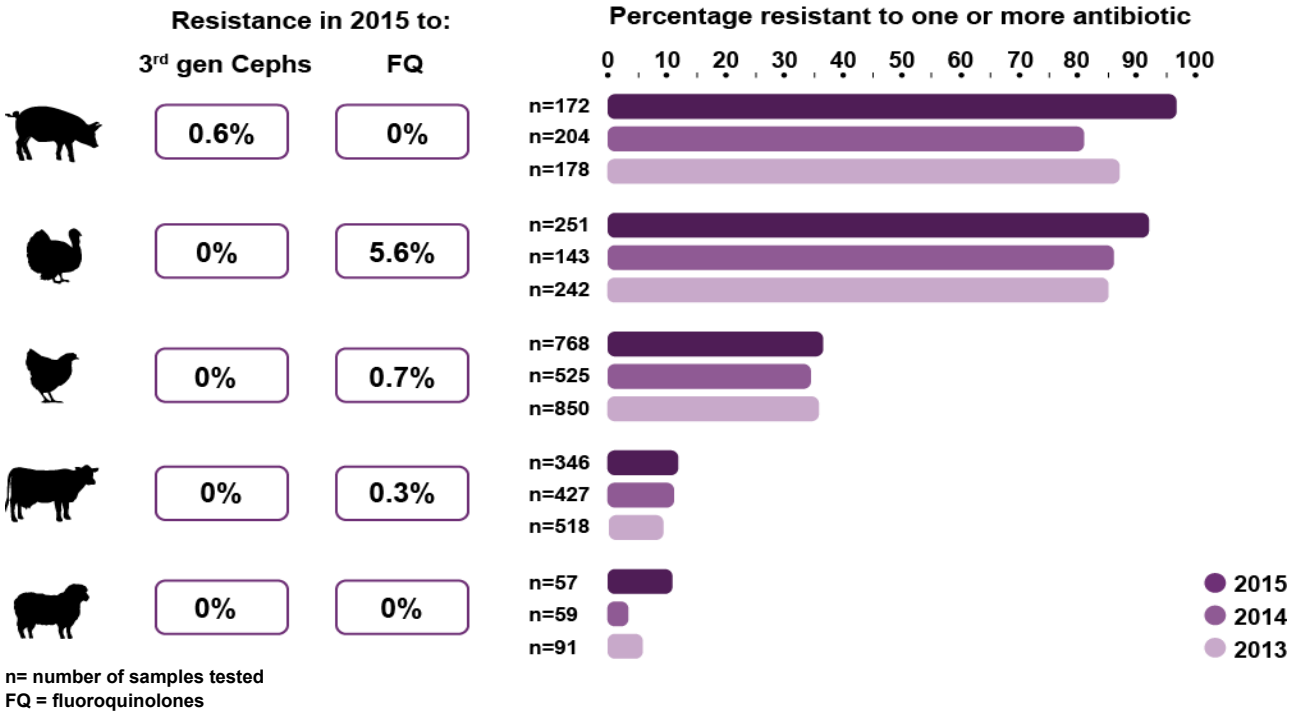
Of the 150 isolates of *E. coli* tested, 1% were resistant to ciprofloxacin; none were resistant to cefotaxime, ceftazidime or colistin. However, following enrichment, presumptive extended spectrum ß-lactamase (ESBL) producing *E. coli* were detected in 24.7% of 327 caecal samples. No carbapenemase or OXA-48 producing *E. coli* were detected in 294 caecal samples cultured on selective agar.



*** To note this testing does not identify the type or number of ESBLs present**

Salmonella isolates resistant to one or more antibiotic (%) from clinical surveillance

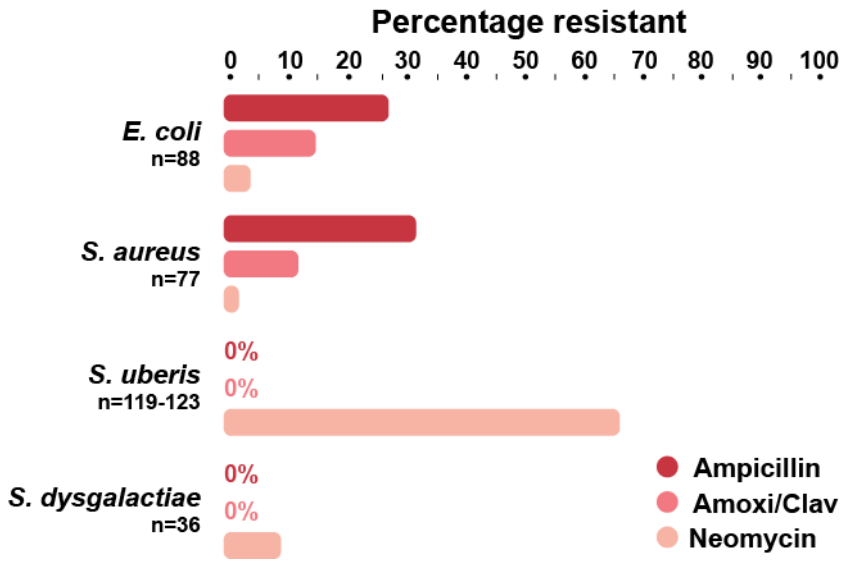
In total, 1594 *Salmonella* isolates from cattle, sheep, pigs, chickens and turkeys were tested. Resistance to the highest priority critically important antibiotics was very low with 1.3% (20/1594) of all *Salmonella* from all species resistant to ciprofloxacin (FQ) and 0.1% were resistant to cefotaxime and ceftazidime.



n= number of samples tested
FQ = fluoroquinolones

Resistance level in mastitis pathogens (%) from clinical surveillance

Resistance demonstrated by bovine mastitis pathogens was broadly similar to previous years. Resistance to antibiotics commonly used in the treatment of mastitis did occur but varied between pathogens, highlighting the value of culture and sensitivity testing in the treatment of mastitis cases.



n = number of samples tested

Other observations of interest

- 0.6% of 313 samples from randomly sampled pigs, and 1.2% of 163 isolates from clinical surveillance, were positive for the *mcr-1* gene.
- Overall the level of resistance was low in bacteria associated with respiratory disease in sheep and cattle.
- Resistance to tiamulin in *Brachyspira hyodysenteriae* has been highlighted in previous reports due to the serious impact it could have on pig health and welfare. Of the five isolates tested in 2015, one was resistant.
- Livestock-associated meticillin-resistant *S. aureus* (LA-MRSA) ST398 was detected in a pooled caecal sample from pigs, collected at slaughter as part of a research project.
- None of the 63 isolates of *Streptococcus suis* that were tested were resistant to penicillin.
- *E. coli* isolates from a combination of all livestock species were most frequently resistant to streptomycin, tetracycline and ampicillin. Resistance to the highest priority critically important antibiotics tested was generally low, with 9.3% resistant to cefotaxime, 7.2% resistant to cefpodoxime, and 10.7% resistant to enrofloxacin.

Introduction

Antimicrobial resistance has continued to maintain its high profile internationally at the highest levels in 2016, culminating in the adoption of a declaration on AMR at the 71st General Assembly of the United Nations in New York in September. 2016 also saw the World Organisation for Animal Health (OIE) draw together its many workstreams on AMR into an adopted strategy for Combatting Antimicrobial Resistance through a One Health Approach (OIE, 2016) and the United Nations Food and Agriculture Committee adopt its Action Plan on Antimicrobial Resistance 2016-2020 (FAO, 2016).

In Europe, 2016 represents the final year of the European Commission's five year Action Plan against the Rising Threats from Antimicrobial Resistance, and the Commission recently announced its intention to propose a new action plan in 2017 with the objective of preserving the efficacy of antimicrobials for humans and animals, and identifying coherent action to that end (European Commission, 2016).

The past year saw publication of the final report and recommendations of the AMR Review chaired by Lord Jim O'Neill (Review on AMR, 2016), an independent review with a focus on economic aspects of AMR, which was commissioned in 2014 by the previous Prime Minister. The government published its formal response to the review, setting out how the recommendations would be taken forward. For animal health, the three highest profile government commitments are around the introduction of targets for the reduction of antibiotic use in animals, and strengthening stewardship in animals of antibiotics which are of greatest importance to human health. As set out in the UK's 5 Year AMR Strategy, high levels of animal health and welfare and good disease control are essential factors in underpinning the success of these ambitions in a long-term and sustainable way.

The first two chapters report on the data available and the data which will become available, for measuring the success of reducing antibiotic use. Our top-level multi-species target is to reduce antibiotic use from 62 mg/kg (2014 data) to 50 mg/kg by 2018. We report a reduction of approximately 10%. This is a good step towards the 50 mg/kg target; while antibiotic use can fluctuate with a number of external factors such as disease outbreaks in a given year, differing degrees of reduction have been seen across the board in products authorised for different species and for all major classes of antibiotics.

The question remains, how appropriately low is possible for antibiotic use? This is where engagement with the veterinary profession and farming industry is critical. We are committed to have industry-led, sector-specific targets for reduction in antibiotic use in place by 2017. The introduction to last year's VARSS report highlighted the potential opportunity for data on consumption of antibiotics by different animal species to be collected, together with information on health/disease status of the animals. Such systems are now being put in place. Recognising that for data to be useful to vets and farmers at a local and farm level, sectors may identify measures/ parameters which will be of most use for informing and encouraging reduction of antibiotic use in the context of responsible use and optimal stewardship of antibiotics. It's also clear that different sectors are at different stages in developing such monitoring systems. While the focus will remain on the three priority sectors of pigs, poultry and cattle, optimal stewardship of antibiotics is a

responsibility in every species and we look forward to seeing how the other animal sectors rise to this challenge.

The EU harmonised monitoring programme, which evaluates resistance in bacteria of public health importance which have been isolated from healthy animals, recognises the potential for certain bacteria to present a route of AMR transmission from animals to people. This programme is designed to give results representative of each country's pig population and uses methodology harmonised across Europe. The findings for 2015 will be published by EFSA next February in the annual "Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food".

In line with previous years' format, the final chapter reports antibiotic resistance results from clinical samples taken from veterinary patients in England and Wales. However, for the first time this year we have included resistance data for *E. coli* and *Salmonella* from Scotland and Northern Ireland, courtesy of colleagues in those Devolved Administrations. Work remains to harmonise methodology for determining resistance.

2016 has been a year of building momentum, reaffirming and updating old commitments, and making new ones. There has been much action by the veterinary profession and in the key livestock species sectors which has contributed to the 10% reduction of antibiotic sales during 2015. However, currently the only sector that can evidence this is the meat poultry industry. That is because they have the antibiotic use data to show accurately what antibiotics were used in meat poultry, and by doing this in tandem with implementation of their stewardship plan, have been able to explain how these reductions have been achieved. Other sectors are on their way to achieving this.

We very much look forward to continuing to work collaboratively with all interested parties to maintain momentum generated, and we also very much look forward to next year's VARSS report in anticipation of further insights into our collective progress on improving the responsible use of antibiotics in animals.

Professor S. Peter Borriello
Chief Executive Officer

Chapter 1: Sales of Veterinary Antibiotics

Introduction

The quantity of authorised veterinary antibiotics sold throughout the UK has been reported to the VMD by pharmaceutical companies since 1993 and this has been a statutory requirement since 2005 (Annex 1). The data represented do not take into account wastage, imports or exports of veterinary antibiotics, but they serve as the best currently available approximation of the quantity of antibiotics administered to animals in the UK. The VMD sends these data annually to the European Medicines Agency, where they are collated with equivalent data from other European countries and published in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) report on sales of veterinary antibiotics in 29 European countries. In keeping with most other European countries, the UK does not yet have a comprehensive system which can collect and collate data on antibiotic use by animal species. However, such systems are under development and discussed further in Chapter 2.

Method

In previous UK-VARSS reports (2013 and 2014) the methodology used for the calculation of the amount of active ingredient in each antibiotic product, and the mg/PCU calculation, has differed from the European methodology, as used in the annual ESVAC reports. In order to provide harmonisation, the quantity of active ingredient sold will now be reported using the European methodology, which has been developed and implemented by ESVAC. All sales data published in this chapter have been updated to reflect these changes. An explanation of the changes to the methodology can be found in Annex 1.

Annual sales of all authorised veterinary medicines are supplied by Marketing Authorisation Holders (MAH) to the VMD, where they are collated and validated. From these data, the total weight in tonnes of each antibiotic active substance is calculated. The data reported here are presented according to the ATCvet classification system (www.whocc.no/atcvet/). Antibiotic agents for intestinal use, intrauterine use, systemic use and intramammary use are included, but sales of dermatological preparations and preparations for sensory organs (described as “other” route of administration in previous UK-VARSS reports) are not included.

Trends in sales of antibiotics between years and between different countries cannot be determined without taking into consideration variations in the number and size of the animals that may have been treated. Therefore sales data are analysed using the Population Correction Unit (PCU), a theoretical technical unit of measurement adopted by countries across Europe to standardise sales against the animal population denominator. Using the PCU, the overall sales of products authorised for use in food producing species can be presented as mg/PCU. This enables year-on–year, and country, comparisons to be made. Further details on these calculations are presented in Annex 2 and full technical details on PCU methodology can be found in the 2009 ESVAC report (ESVAC, 2011).

There are a number of limitations when analysing sales data. They cannot, for example, tell us the number, dose and duration of treatments or the extent to which prescribing was appropriate or inappropriate. Reducing treatment duration or dose, for example, would be likely to represent inappropriate prescribing. Further, the results do not tell us whether antibiotics were prescribed for treatment, metaphylaxis or preventative use.

From sales data it is also not possible to identify the species in which the antibiotics were used. This is for two reasons:

1. Many products are authorised for use in more than one animal species. In particular, a large number of products are authorised for use in both pigs and poultry.
2. The 'prescribing cascade' makes provision that, under certain circumstances, medicines may legally be administered to species for which they have not been authorised. This is known as 'off-label' use, and there is no way of knowing what proportions of products sold have been administered under the cascade in this way. More details on the cascade are available in Annex 5.

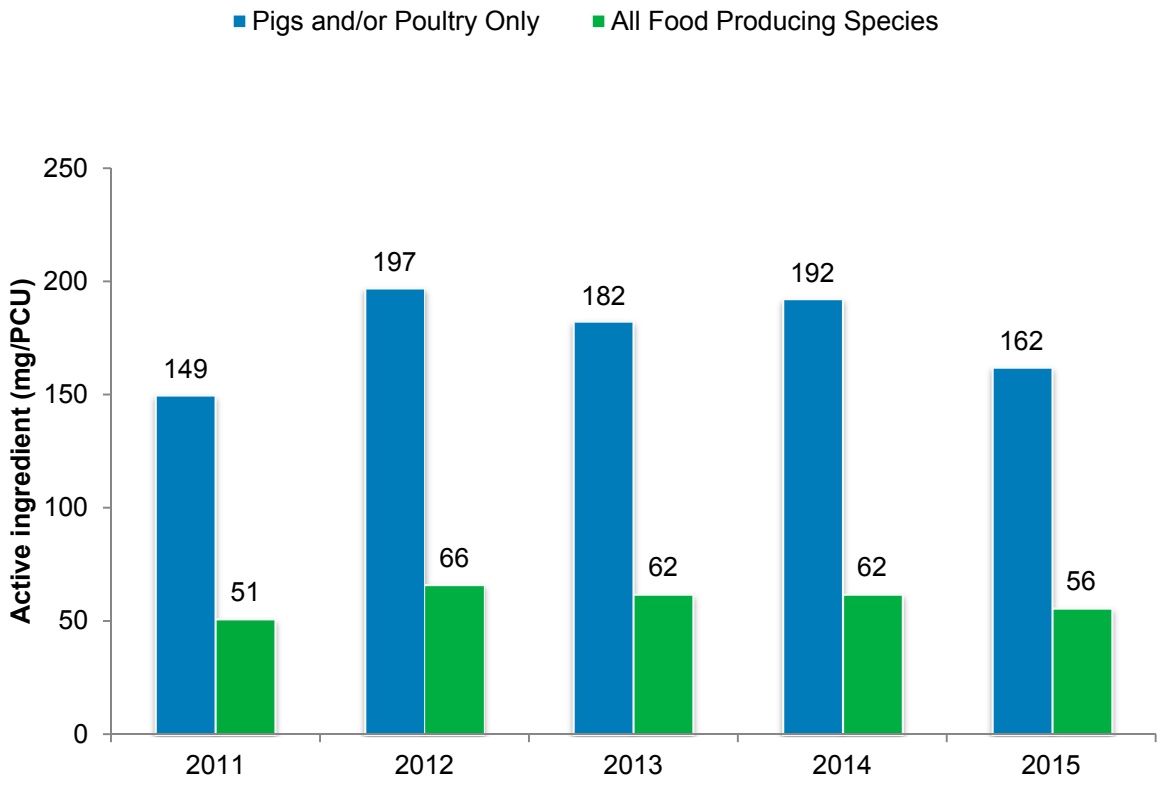
Contributing pharmaceutical companies are listed in Annex 21.

Sales of Antibiotics for Food Producing Animals

The mg/PCU figure is the most appropriate parameter to use when comparing antibiotic sales year-on-year, as it considers changes in the number and relative size of animals in the population. The mg/PCU can be considered as the average quantity of active substance sold per kilogram bodyweight of food producing animal treated in the UK over the course of the year.

The mg/PCU figure for all food producing species decreased by 10% (6mg/PCU) between 2014 and 2015, and the combined pig and poultry mg/PCU decreased by 16% (30mg/PCU). These are the second lowest figures reported over the last five years. However the lowest figures (in 2011) are considered to be artificially low due to changes in Marketing Authorisation Holder for a small number of food-producing animal products between 2010 and 2011, which led to stockpiling in 2010 (due to concerns about availability) and subsequently lower purchasing during 2011. This is discussed in more detail in the 2012 VARSS report (VMD, 2013).

Figure 1.1: Milligrams (mg) of active ingredient of antibiotic sold for pigs and/or poultry only and all food producing species per Population Correction Unit (PCU) 2011-2015 (calculated using ESVAC methodology, see Annex 1 for more detail)

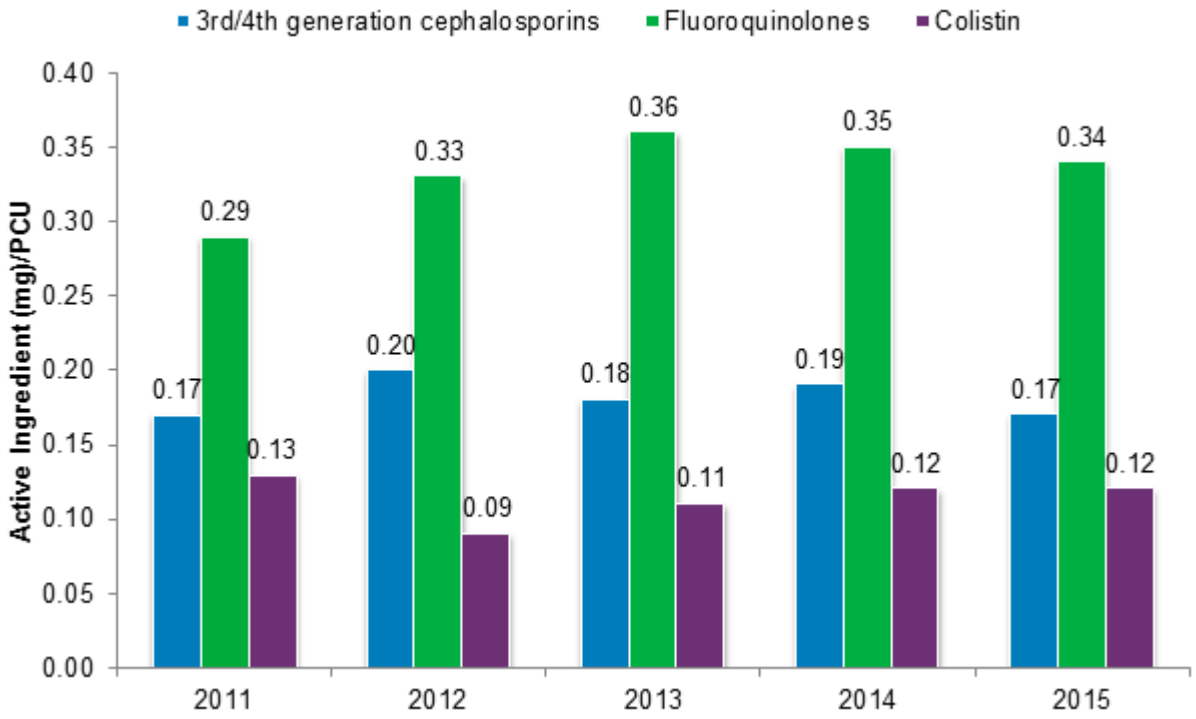


Antibiotics of Particular Relevance to Human Health

Certain antibiotic classes are categorised by the World Health Organisation (WHO) as critically important antibiotics (CIA) for human use, of which macrolides, fluoroquinolones and 3rd and 4th generation cephalosporins are designated as 'highest priority critically important antibiotics' (HP-CIA) (WHO, 2011). In December 2014, the European Medicines Agency (EMA) published scientific advice on the risk to humans from antibiotic resistance caused by the use of HP-CIAs in animals. This advice classed macrolides as category 1, which means the risk of use in animals to public health is low or limited, whereas fluoroquinolones and 3rd and 4th generation cephalosporins were classified as category 2, which means the risk for public health is considered higher. This advice was subsequently updated to take into account new data on colistin resistance, and the expert group recommended that colistin was moved to category 2, alongside fluoroquinolones and 3rd and 4th generation cephalosporins.

On this basis, the presentation of more detailed information on antibiotics of relevance to human health is focused on fluoroquinolones, 3rd and 4th generation cephalosporins and colistin. Figure 1.2 shows the sales of these antibiotics in mg/PCU. Sales of HP-CIAs make up a small proportion of the 56 mg/PCU overall all-antibiotic use in livestock and have remained stable over the last 5 years.

Figure 1.2: Milligrams (mg) of active ingredient of "highest priority critically important antibiotics'' sold for food producing species per Population Correction Unit (PCU) 2011-2015



Sales of Veterinary Antibiotics Containing Colistin

Following the discovery, in China in November 2015, of a novel colistin resistance gene capable of horizontal transmission (*mcr-1*) the European Medicines Agency (EMA) Antimicrobial Expert Group (AMEG) updated their advice to the European Commission (EC) on the use of colistin products in animals and the development of resistance, and any possible impact on human and animal health.

http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000639.jsp&

The expert group recommended that colistin should be added to the AMEG list of higher risk critically important antibiotics (category 2) that currently includes fluoroquinolones and 3rd and 4th generation cephalosporins. The AMEG's advice also recommended that, for countries which are "high and moderate" consumers of colistin, a target for reduction should be set at 5 mg/PCU, whereas for countries whose use is already below this level, the target should be set at 1 mg/PCU. The AMEG were clear that these targets should be met without increasing the use of fluoroquinolones, 3rd and 4th generation cephalosporins or overall consumption of antimicrobials.

The sales of veterinary antibiotic products containing colistin in the UK are low and have remained stable over the past five years, with less than 1 tonne being sold annually, and the mg/PCU staying consistently well below the lower recommended 1mg/PCU target.

The finding of the *mcr-1* gene in China, and subsequently in the UK and other countries across the world (Vet Times, 2015) was published at the end of 2015. For this reason, the 2015 UK sales data reported here will not reflect voluntary measures that the UK livestock industries took to reduce colistin use after the discovery of the novel resistance was reported.

Sales of Intramammary Antibiotic Products

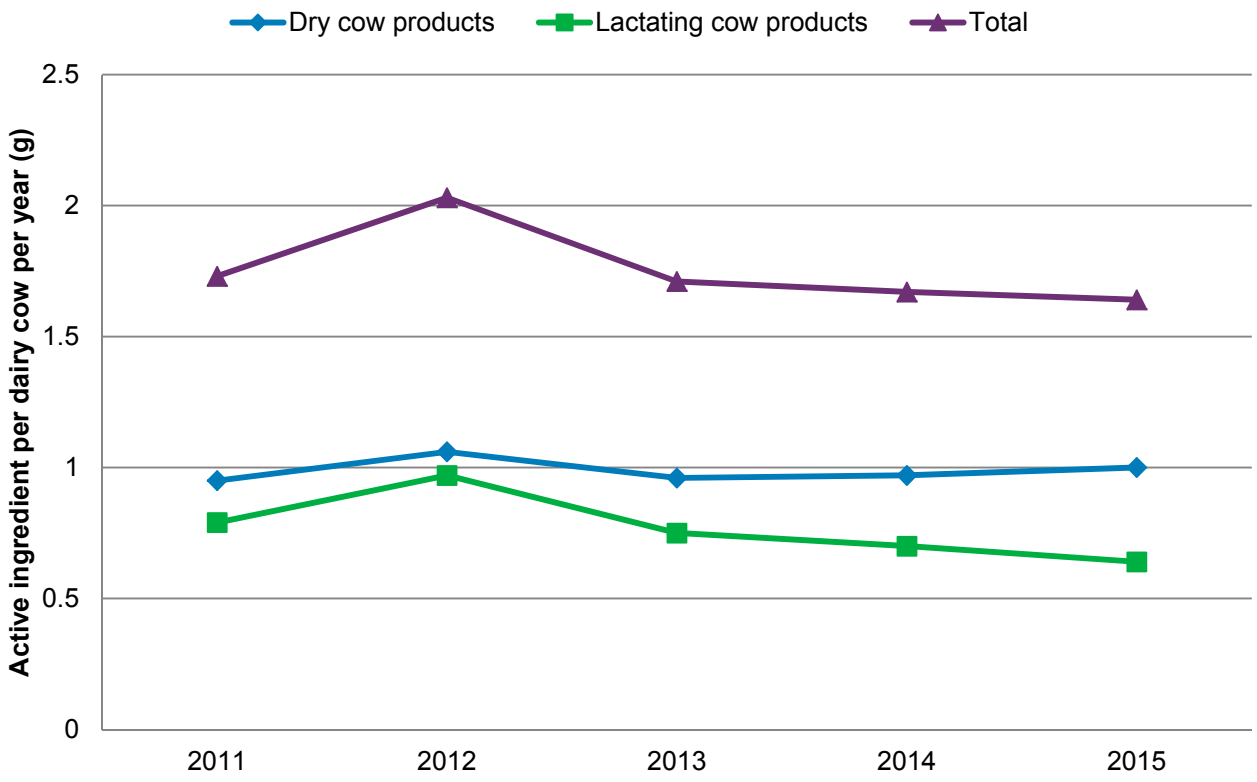
Table 1.1 and Figure 1.3 below show that the sales of products for lactating cows decreased by 6% (80kg of active substance) and the average amount per dairy cow decreased by 9% (0.06g/animal) between 2014 and 2015. This is the lowest level reported over the last 5 years. Sales of dry cow products have remained stable between 2014 and 2015.

Table 1.1: Kilograms (kg) and (average amount in grams per dairy cow*) of active ingredient of intramammary antibiotics sold 2011-2015

	2011	2012	2013	2014	2015
Dry Cow Products	1698 (0.95)	1895 (1.06)	1716 (0.96)	1782 (0.97)	1898 (1.0)
Lactating Cow Products	1417 (0.79)	1750 (0.97)	1331 (0.75)	1289 (0.70)	1209 (0.64)
Total	3114 (1.73)	3645 (2.03)	3047 (1.71)	3072 (1.67)	3107 (1.64)

*based on number of dairy cows in the national herd in each respective year

Figure 1.3: Average annual amount in grams (g) of active ingredient of intramammary antibiotic sold per dairy cow 2011-2015



Total Sales by Weight and Antibiotic Group (indicated for all species)

The total quantities of antibiotic active substance in products sold between 2011 and 2015, and their breakdown by class, are shown in Table 1.2 and Figure 1.4. Definitions of these classes, and the active ingredients that are included, can be found in Annex 3. The total quantity of antibiotics sold in 2015 was 404 tonnes, which is a decrease of 9% from 2014. As previously discussed, however, tonnage is a less meaningful way of monitoring trends than mg/PCU as it does not take into account variations in UK livestock weights and numbers.

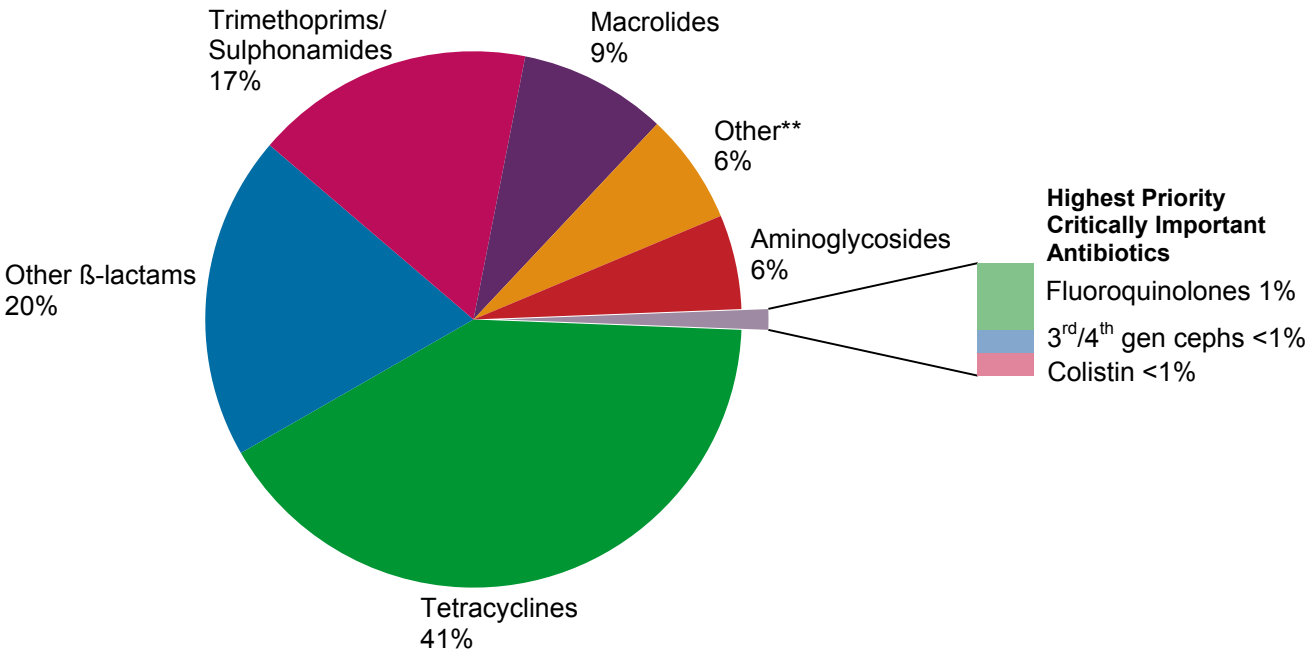
Table 1.2: Tonnes of active ingredient of antibiotic sold for all species by class and total sales 2011-2015

		2011	2012	2013	2014	2015
Tetracyclines		115	201	194	181	166
Trimethoprims/ Sulphonamides		72	80	61	71	68
Trimethoprims		12	13	10	12	11
Sulphonamides		60	66	51	59	57
ß-lactams		89	94	94	95	80
1st/2nd Generation Cephalosporins		5	5	5	5	5
3rd/4th Generation Cephalosporins	(t)	1	1	1	1	1
	(kg)*	1166	1328	1192	1332	1202
Penicillins**		20	19	20	12	9
Other Penicillins***		63	69	68	77	65
Aminoglycosides		20	22	24	24	23
Streptomycins		9	10	11	9	10
neomycin and framycetin		1	1	1	1	1
Other aminoglycosides****		9	12	9	14	13
Macrolides		37	41	40	48	36
Fluoroquinolones	(t)	2	2	3	3	3
	(kg)*	2084	2381	2562	2590	2529
Other***		22	24	21	24	27
Colistin	(t)	0.87	0.61	0.73	0.84	0.87
	(kg)*	866	606	728	837	870
Total		**357**	**464**	**436**	**445**	**404**×

*Because of the heighted interest in HP-CIA classes the sales of fluoroquinolones, 3rd and 4th generation cephalosporins and colistin are displayed in kg as well as tonnes.
**includes benzylpenicillin, benzathine penicillin, phenoxymethylpenicillin, procaine penicillin
***includes amoxicillin (including in combination with clavulanic acid), ampicillin, cloxacillin, nafcillin
****includes apramycin, gentamycin, kanamycin, spectinomycin
*****includes: amphenicols, lincomycins, pleuromutilins, polymixins and steroidal antibiotics. Colistin sales are included within this group.
× For each of the antibiotic classes, the total was rounded to the nearest integer. This explains the discrepancy between the overall total and the classes' totals.

The sales of different classes of antibiotics in 2015 are shown in Figure 1.4, which highlights that tetracyclines, β-lactams (including penicillin) and trimethoprim/sulphonamides account for the majority (>75%) of active substances sold.

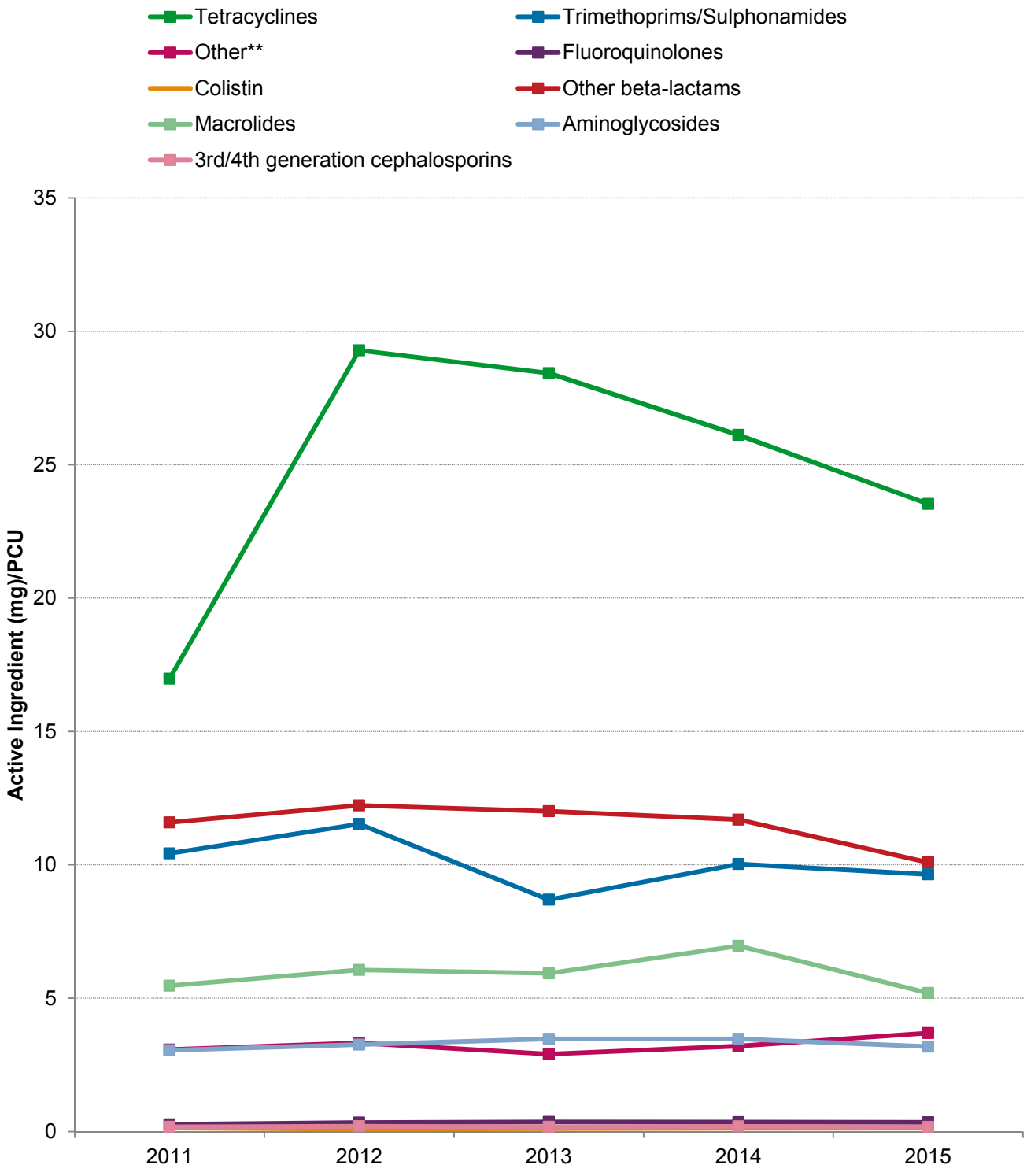
Figure 1.4: Percentage of active ingredient of antibiotic by class sold for all species in 2015



**Other includes: amphenicols, lincomycins, pleuromutilins, polymixins and steroidal antibiotics.

In 2015, there was a decrease in the sales of all antibiotic classes, with the exception of the group of products classified as 'other' (Fig. 1.5). Note that, as described in the 2012 VARSS report, the tetracycline sales in 2011 are considered to be artificially low due to stockpiling in 2010 (caused by concerns about availability following a change in Marketing Authorisation Holder) and subsequently lower purchasing during 2011. This is discussed in more detail in the 2012 VARSS report.

Figure 1.5: Milligrams (mg) of active ingredient of antibiotic by class sold for food producing species per Population Correction Unit (PCU) by class in 2011-2015



**Other includes: amphenicols, lincomycins, pleuromutilins, polymixins and steroidal antibiotics.

Sales by Animal Species Indicated

The quantities of antibiotic active substance in products sold between 2011 and 2015 are shown in Table 1.3 and Table 1.4, differentiated by the species or combination of species for which they are indicated. In the UK, the role of horses is predominantly as a companion or sport animal and therefore horses pose limited public health risk from food borne transmission. For this reason, in tables 1.3 and 1.4 horses are grouped with companion animals while farmed food producing species are grouped together. Please note, however, that when calculating the mg/PCU, horses are included as a food producing species, in line with ESVAC methodology (see Annex 1).

Table 1.3: Tonnes and (% of total sales) of active ingredient of antibiotic sold by species category indicated and total sales 2011-2015

	2011	2012	2013	2014	2015
Indicated for farmed food producing animals only	300 (84%)	396 (85%)	368 (84%)	383 (86%)	344 (85%)
Indicated for companion animals and/or horses only	34 (10%)	35 (8%)	36 (8%)	32 (7%)	25 (6%)
Indicated for a combination of both food and non-food producing species	23 (6%)	33 (7%)	32 (7%)	30 (7%)	35 (9%)
Total sales of antibiotics	357	464	436	445	404

The proportions of antibiotics sold across each of the three categories above have remained similar over the past five years.

In 2015, 87% of active substance sales from antibiotic products authorised only for farmed food producing animals were for pigs and/or poultry, and no other species (Table 1.4). Products for multiple livestock species (excluding those authorised solely for pigs and/or poultry) accounted for 8% of antibiotics sold for farmed food producing animals in 2015 (Table 1.4).

Table 1.4: Tonnes of active ingredient of antibiotic sold for farmed food producing species only, by species category indicated 2011-2015

Product indicated exclusively for:	2011	2012	2013	2014	2015
Pigs and poultry only	154	235	217	235	212
Pigs only	64	66	63	66	50
Poultry only*	41	47	43	43	38
Multiple farmed food producing species**	27	32	30	24	28
Cattle only	12	14	14	13	14
Fish only	2.1	2.1	0.8	2.4	0.7
Sheep only	0.1	0.2	0.2	0.1	0.2

*In previous reports, products authorised for use in 'ducks' in combination with other poultry species have been included in the 'multiple livestock species' category. These products have been included in the 'poultry only' category in this table and all historical data have been updated. This change affects those data reported in previous UK-VARSS reports for 'pig and poultry only', 'poultry only' and 'multiple farmed food producing species'

** Not including products indicated for pigs and poultry only, horses or products indicated for a combination of both farmed food and non-food producing species.

Sales by Route of Administration

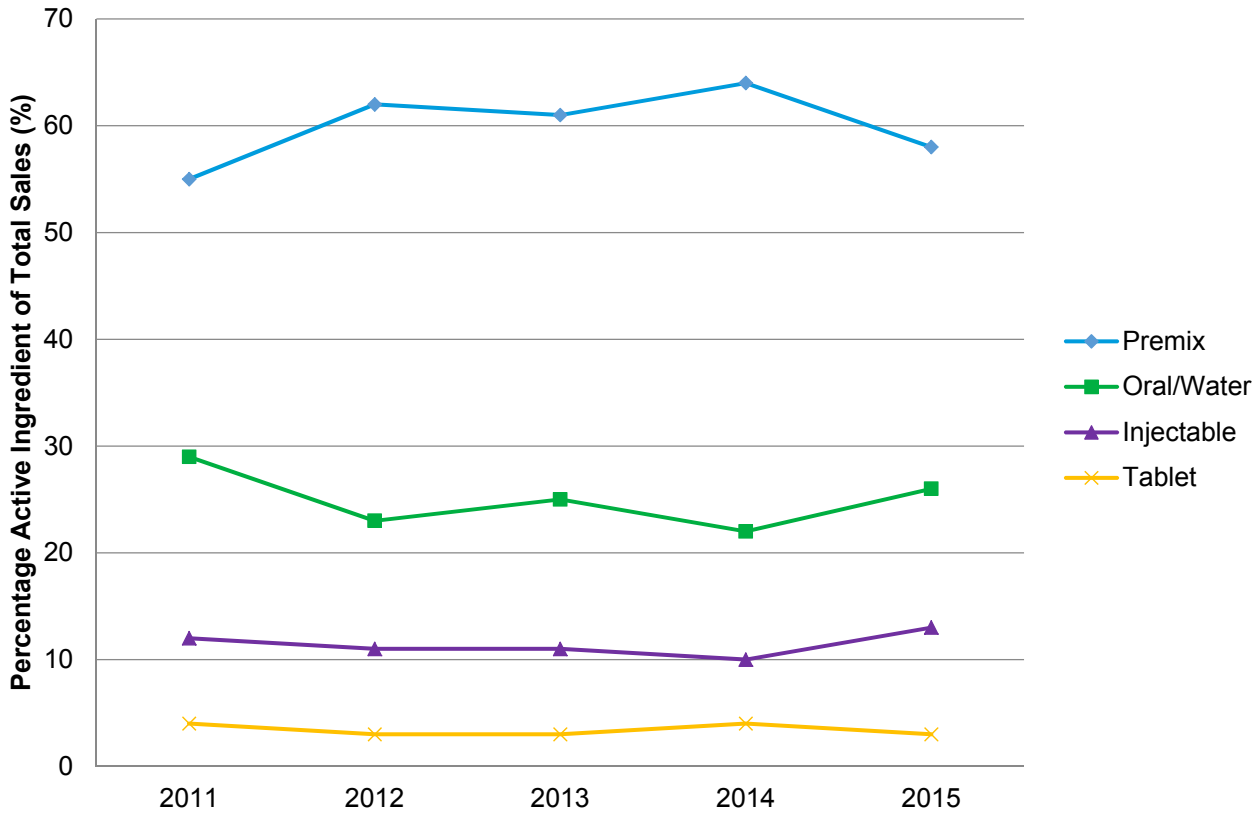
The main routes of administration of veterinary antibiotics sold for all species in 2011-2015 are listed in Table 1.5 and shown in Figure 1.6. Premixes and oral/water soluble products (not including tablets) accounted for 57% and 26% respectively of the total antibiotics sold in 2015.

Table 1.5: Tonnes and (% of total sales) of active ingredient of antibiotic sold for all species by route of administration 2011-2015

	2011	2012	2013	2014	2015
Premix	195 (55%)	287 (62%)	263 (60%)	281 (63%)	232 (57%)
Oral/Water*	103 (29%)	108 (23%)	109 (25%)	100 (22%)	105 (26%)
Injectable	43 (12%)	49 (11%)	47 (11%)	45 (10%)	51 (13%)
Tablets	13 (4%)	16 (3%)	14 (3%)	16 (4%)	12 (3%)
Intramammary	3 (<1%)	4 (<1%)	3 (<1%)	3 (<1%)	3 (<1%)
Total	357	464	436	445	404

* Excluding tablets

Figure 1.6: Percentage of active ingredient of antibiotic sold for all species by route of administration 2011-2015



Chapter 2: Data Collection Activities to determine the level of Antibiotic Usage by Livestock Species

Introduction

Antibiotic usage refers to the amount of antibiotics purchased, prescribed and/or administered. Many antibiotics are authorised for use in multiple species, so it is not possible to determine how much is used per species from sales data. The VMD is therefore working in partnership with key livestock sectors to develop, facilitate and coordinate collection systems for the priority livestock species (pigs, poultry and cattle).

Capturing antibiotic usage data per species will provide a baseline against which trends and the effect of interventions, such as those designed to reduce antibiotic use, can be measured. The data can also be used to investigate risk factors for high levels of antibiotic use and the effect of use on the development of resistance. Collection systems will also allow for benchmarking, enabling farmers to compare themselves with their peers and encouraging vets and farmers to identify and share good practice.

This chapter describes the progress achieved so far, with updates from each of the priority livestock sectors. For the second year running, total antibiotic usage has been provided by the British Poultry Council (BPC) and this is presented in Annex 4.

Poultry

Contribution from the British Poultry Council:

The British Poultry Council (BPC) represents more than 90% of the UK poultry meat production, and its Antibiotic Stewardship Scheme was established in 2011. This involved the formation of an expert working group of poultry meat producers and poultry veterinarians to identify a programme of work designed to promote the responsible use of antibiotics. One of the first actions of this group in 2012 was to ban the use of all cephalosporins in flocks used for poultry meat production, and to establish its commitment to stop the prophylactic use of fluoroquinolones in day old chickens. In 2015, the BPC membership stopped the use of colistin in its flocks, and in 2016, a further commitment was made to stop the prophylactic use of fluoroquinolones in day old chickens. In 2014, BPC members became the first livestock sector to voluntarily submit to the VMD antibiotic usage data collected from poultry meat producers. These data (Annex 4) show that members of the BPC Antibiotic Stewardship Scheme reduced their use in 2015 by 27% compared to 2014, which included a 52% reduction in the use of fluoroquinolones. Furthermore over the period 2012-2015, BPC members decreased total antibiotic use by 43%.

Contribution from the British Egg Industry Council:

The egg sector has commenced the second year of data collection, where all egg producers, pullet rearers and breeding companies are required to report any use of an antibiotic to their subscriber. This data is reported to the BEIC on a quarterly basis so that an accurate measurement of the amount of antibiotics used on a 'chicken medication day' basis can be recorded and disseminated more widely as required. Our ambition is to be in a position where we can share data with the VMD in 2017 which will help confirm our belief that the egg sector is a low user of antibiotics.

Pigs

Contribution from the Pig Health and Welfare Council (PHWC) Antimicrobial Usage Sub-group:

The PHWC Antimicrobial Usage Sub-group continues work to implement the action plan to promote the responsible use of antibiotics in UK pig production, which was developed from an industry wide workshop held in October 2014. In the last year, there has been significant progress in collecting data on antibiotic usage from UK pig farms following the launch by AHDB-Pork in April 2016 of an electronic medicines book (eMB-Pigs).

eMB-Pigs allows farmers to report antibiotic usage, monitor and benchmark their use with other farms and help them meet their obligations for antibiotic recording under farm quality assurance schemes. By the end of October 2016, 534 sites had signed up to eMB-Pigs, covering 17% of national pig production (2,544,186 finishers, 2,988,379 weaners and 371,580 sows and boars). AHDB-Pork are continuing to work with the large corporate pig producers, to encourage bulk data uploads to be provided, with feed companies, to encourage feed data to be uploaded directly into eMB-Pigs, and farm software companies, to promote data sharing. While it is still early days, and the data submitted need to be verified, it is hoped that 2016 aggregated, anonymised usage data will be included in the 2017 VARSS report.

In addition, and in conjunction with the subgroup, the Pig Veterinary Society (PVS) has produced guidelines for veterinary surgeons attending pigs on the need and procedure for regular clinical review of the use of antimicrobials in their clients' pigs. The PVS has made the Society's prescribing principles for antimicrobials available to all vets, not just PVS members, on their website. The National Pig Association (NPA) have also launched a Pig Industry Antibiotic Stewardship Programme in a bid to ensure and demonstrate responsible use of antibiotics in pigs, and have been working with PVS, AHDB-Pork, and the Veterinary Medicines Directorate, to progress its initiatives.

Cattle

Contribution from the Cattle Health and Welfare Group:

In 2014, the VMD commissioned the Cattle Health & Welfare Group (CHAWG) to undertake a scoping study to ascertain what antibiotic usage data are currently being collected and what should be done to develop data collection systems in the UK cattle sector (both dairy and beef). The 2015 study, and a follow up industry workshop in January 2016, concluded that there is a strong willingness to develop a robust and effective monitoring system but, although there are a number of individual initiatives, there is currently no central data collection point for the cattle industry.

A two stage process has been proposed, that will initially collects farm level dispensing and prescription data from veterinary practice records. This could then be followed by an industry agreed approach to collecting usage information directly from the farm. An industry working group, the Cattle Health and Welfare Group (CHAWG) Antimicrobial Usage Data Collection Steering Group, was established in June 2016 to agree on a way forward, and it is hoped that a system will be up and running by the end of 2017.

Future Plans

In the coming year the VMD's focus will be to continue working with stakeholders to build on the activities and strategies outlined above, in particular increasing the number of farms using e-MB-Pigs and continuing to develop a data collection system for the cattle industry. Sector specific targets will also be developed, led by the industry, which will form the long-term, sustainable, evidence based basis for underpinning responsible use, and sharing examples of best practice in UK agriculture.

We will also continue to work with ESVAC on development of guidance on the type and format of antibiotic use data per species required and how to measure the total animal population at risk. This will allow collation, analysis and reporting harmonised and standardised data on population-corrected antibiotic use per species across European countries. The proposal will be available for public consultation on 15th December 2016, with a final version to be agreed by 30th April 2017.

Chapter 3: EU Harmonised Monitoring of Antibiotic Resistance

Introduction

EU harmonised monitoring of AMR is a programme set out in EU legislation which aims to evaluate antibiotic resistance in bacteria of relevance to human health which have been isolated from healthy animals. The sample size and sampling strategy have been designed to provide a representative sample which reflects the wider population

Susceptibilities are presented as human clinical break points (CBPs) in this report and epidemiological cut-off values (ECVs).

- CBPs relate laboratory results to likely clinical treatment success or failure. Therefore, 'resistant' results using CBPs correspond to a likelihood of treatment failure when using an antibiotic to treat a clinical infection caused by that bacterial isolate.

- ECVs represent the point at which bacteria have developed a higher level of resistance to an antibiotic than the background level of resistance that exists naturally for that bacterial species. A 'resistant' (or 'non-susceptible') ECV does not necessarily imply a level of resistance which would correspond with clinical treatment failure.

Susceptibilities interpreted using both ECVs and human CBPs are provided in full in the main body of the report, or in Annex 10.

Surveillance conducted in livestock under EU Harmonised Monitoring in 2015

The EU harmonised monitoring legislation (Commission Decision 2013/652/EU) 'on the monitoring and reporting of antimicrobial resistance in zoonotic and commensal bacteria' mandates all EU Member States to monitor AMR in specified bacteria in food producing animals at slaughter, and food products at retail. An overview of this sampling plan, by year, is summarised in Annex 6.

In 2015, Member States were mandated to carry out three sets of testing:

- Susceptibility testing of randomly selected *Escherichia coli* isolates obtained from the caecal contents of pigs at slaughter
- Testing for the presence of Extended Spectrum β-Lactamase (ESBL), AmpC, and carbapenemase producing *E. coli* in caecal contents of pigs at slaughter using selective media. The method screens large numbers of *E. coli* and can detect low numbers of resistant organisms.
- Susceptibility testing of *Salmonella* isolates derived from pig carcass swabs taken by food business operators at the end of processing

Selection of isolates for susceptibility testing was based on the criteria laid down in EU technical specifications (Commission Decision 2007/516/EC). This protocol for testing *E. coli* from pigs was adopted for the first time in 2015; therefore only one year's worth of *E. coli* resistance data are presented in this chapter.

The importance of these EU surveillance activities and the relevant legislation is three-fold:

- The organisms for which the legislation outlines monitoring provisions, such as *Salmonella* and *E. coli*, are of direct relevance to human health. Additionally, the panel of antibiotics against which these organisms must be tested has been selected based on relevance to human health and includes antibiotics, such as 3rd and 4th generation cephalosporins and fluoroquinolones that are defined by the WHO as the Highest Priority Critically Important Antibiotics (HP-CIA) for human health.
- The legislation and accompanying technical specifications provide a standardised and harmonised sampling methodology which produce comparable and robust susceptibility data for a representative proportion of food producing animals and food products across the EU.
- The legislation provides a harmonised set of ECVs and human CBPs to interpret susceptibility to antibiotics. This will enable the comparison of animal resistance data with similar data generated by human health, both within the UK and across the EU. MICs are also recorded, and will enable any future changes in ECVs or CBPs to be taken into account.

Method

In accordance with Commission Decision 2013/652/EU, 2007/516/EC, and the Microbiological Criteria for Foodstuffs, all of the required tests were conducted by the network of APHA veterinary laboratories located throughout Great Britain. A summary of the three required tests is provided:

- Caeca were collected randomly from healthy pigs at slaughter. *E. coli* were cultured from the caecal samples on non-selective agar, and then a single colony selected from each caecal sample for susceptibility testing against a defined panel of antibiotics using a standardised broth micro-dilution method. Resistance was determined using EUCAST CBPs (see Table 3.1 for results).
- Caecal contents were also enriched and plated on to three types of selective agar (MacConkey + cefotaxime, ChromID OXA-48 and ChromID carba) to test for the presence of ESBL, AmpC and carbapenemase producing *E. coli* (see Table 3.2 for results).
- Carcass swabs were collected by food business operators and then submitted to private laboratories for culture. Where a sample was found to be positive for *Salmonella* the private laboratory was asked to inform APHA and submit isolates for susceptibility testing and serotyping (see Figure 3.2 for results).

Escherichia coli

In 2015, 150 *E. coli* isolates from pig caecal samples collected at slaughter throughout the year were tested for AMR. These *E. coli* were recovered from non-selective media and were randomly-selected. They are likely to represent those *E. coli* most frequently present in the samples, as those which occur more frequently are more likely to be selected when a single colony is chosen for susceptibility testing.

Figure 3.1: Percentage resistance (interpreted using EUCAST CBPs) in *Escherichia coli* isolates from pigs (n=150) in 2015

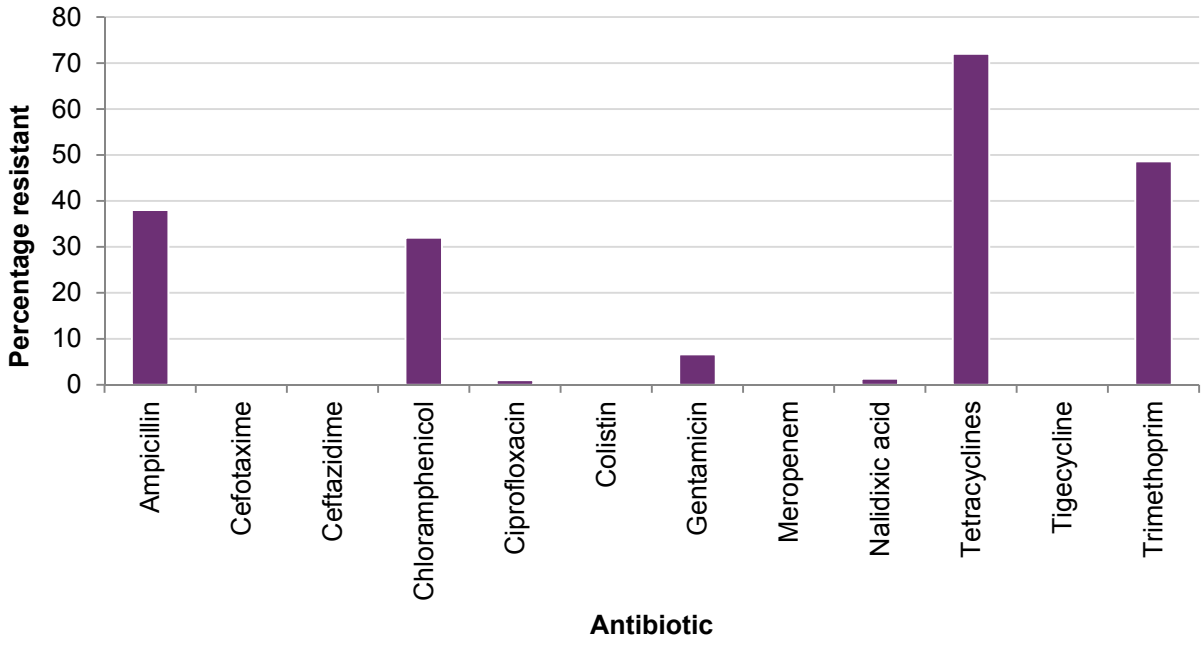


Table 3.1: Resistance in *E. coli* (interpreted using both CBPs and ECVs) from pig caecal samples in 2015

Antibiotic	No. of isolates resistant (%) based on CBPs	based on ECVs
Ampicillin	57 (38%)	57 (38%)
Azithromycin	*	*
Cefotaxime	0 (0%)	0 (0%)
Ceftazidime	0 (0%)	0 (0%)
Chloramphenicol	48 (32%)	47 (31.3%)
Ciprofloxacin	1 (1%)	4 (2.7%)
Colistin	0 (0%)	0 (0%)
Gentamicin	10 (6.6%)	11 (7.3%)
Meropenem	0 (0%)	0 (0%)
Nalidixic acid	2 (1.3%)	2 (1.3%)
Sulphonamide	*	87 (58%)
Tetracyclines	108 (72%)	108 (72%)
Tigecycline	0 (0%)	0 (0%)
Trimethoprim	73 (48.6%)	73 (48.6%)

***E. coli* from pigs (n=150)**

* = No EUCAST breakpoint available

Table 3.2: Results of specific testing for ESBL producing *E. coli* in pig caecal samples following selective culture in 2015

caecal samples yielding *E. coli*	No. (%)
MacConkey agar + 1 mg/L CTX *	81/327 (24.7)
agar selective for carbapenemase producers (Chrom ID CARBA agar) **	0/294 (0)
agar selective for OXA-48 carbapenemase producers (Chrom ID OXA-48 agar) **	0/294 (0)

*These samples originate from unique pig herds from across the UK

**These samples originate from unique pig herds from GB only

Table 3.2 summarises the numbers of samples cultured on each selective agar and the number from which *E. coli* with particular types of resistance were recovered. Whilst these selective methods are effective techniques for defining the presence or absence of ESBL, AmpC and carbapenemase producing *E. coli* in a sample, they do not enumerate or further characterise the *E. coli* present, and therefore are not able to quantify the risk which these bacteria may potentially pose to human or animal health. Selective methods are used to detect low numbers of resistant *E. coli* which may be present as a minor component of the total flora.

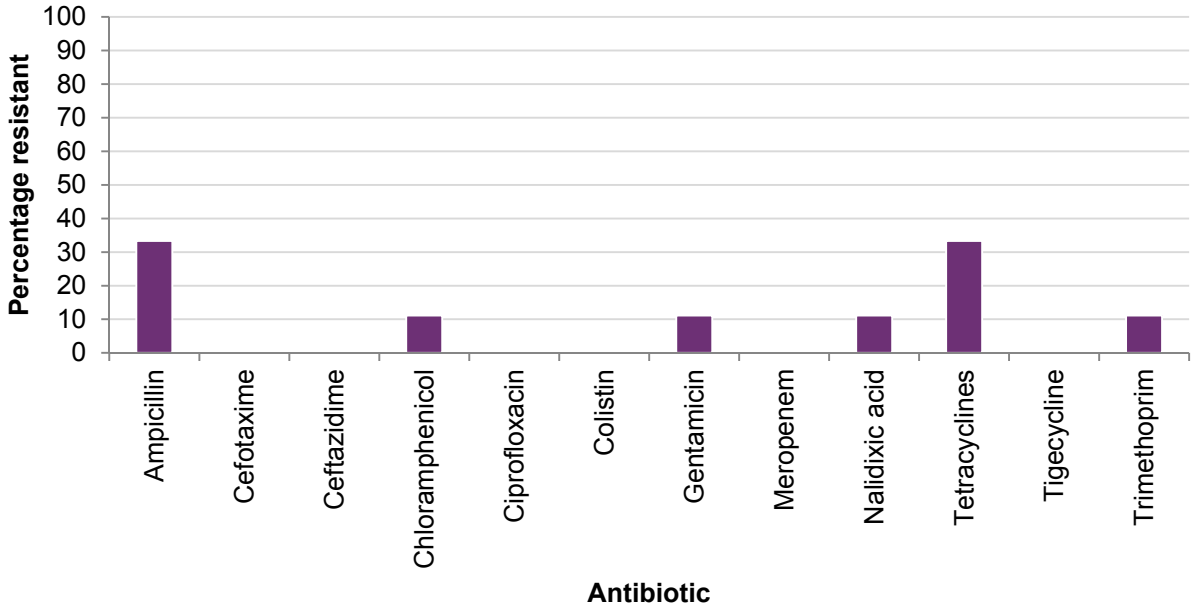
APHA conducted a survey in 2013 to look for ESBL producing *E. coli* in pig caecal samples. A comparison of results and methods of the 2013 APHA survey and 2015 EU monitoring testing can be found in Annex 9.

Salmonella spp.

In 2015, a total of nine *Salmonella* isolates from pig carcass swab samples were examined for AMR (Fig. 3.2). As only a small number of isolates were recovered, the results are not likely to be representative and should be interpreted with caution.

Action has been taken to increase the number of samples received in future years. More details can be found in Annex 7.

Figure 3.2: Resistance (interpreted using EUCAST CBPs) in *Salmonella* spp. from pig carcass swab samples (n=9) in 2015



Chapter 4: Clinical Surveillance of Antibiotic Resistance

Introduction

Clinical surveillance is a programme of passive surveillance, which evaluates antibiotic resistance in bacteria of relevance to animal health which have been isolated from diagnostic samples submitted to APHA. The primary aim of this testing is as a diagnostic service for veterinarians. However, it also serves to identify rare and emerging patterns of resistance, particularly since treatment failure is a frequent reason for submission of material. Any findings that are considered to pose a potential risk to human or animal health are reported to the Defra Antimicrobial Resistance Coordination (DARC) group for consideration and management in accordance with the protocols outlined in the VMD AMR Contingency Plan:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/497125/771046_Contingency_planning_guidance.pdf

The results of this surveillance are compiled to provide an overview of the resistance observed in isolates associated with clinical infections in livestock. This programme relies on the submission of carcasses or other diagnostic samples by private veterinary surgeons APHA veterinary laboratories. These laboratories are situated in England and Wales, with the exception of APHA Lasswade, in Scotland. This chapter reports the APHA methods and results.

Similar programmes are conducted by Scottish (SAC Veterinary Services) and Northern Irish (Agri-Food Biosciences Institute) laboratories. The methods used are detailed in Annex 8 and Annex 18, and data relating to resistance in *Salmonella* and *E. coli* from Scotland and Northern Ireland are presented in Annexes 16 and 17. Where it is clinically relevant, culture and sensitivity testing is undertaken on isolates recovered from submitted samples. Since clinical surveillance is a passive form of surveillance, findings may not be representative of the wider population and therefore are not a prediction of prevalence.

Susceptibility testing methodology

Susceptibility tests were conducted by the network of APHA Veterinary Investigation Centres in England and Wales. For isolates recovered through the clinical surveillance scheme, the susceptibility tests described were performed (unless otherwise stated) using a disc diffusion technique on Isosensitest Agar (Oxoid) with appropriate media supplementation, where necessary, for fastidious organisms, using the method described by the British Society for Antimicrobial Chemotherapy (BSAC,2015).

The disc concentrations used are as stated in Annex 8. Resistance was interpreted using human CBPs as published by BSAC. Isolates have been classed as either sensitive or resistant; under the BSAC guidelines intermediate isolates are considered resistant. For some veterinary ‘drug/bug’ combinations there are no published BSAC breakpoints available. In these cases, a historical APHA veterinary breakpoint (13mm zone size diameter) has been used to indicate resistance.

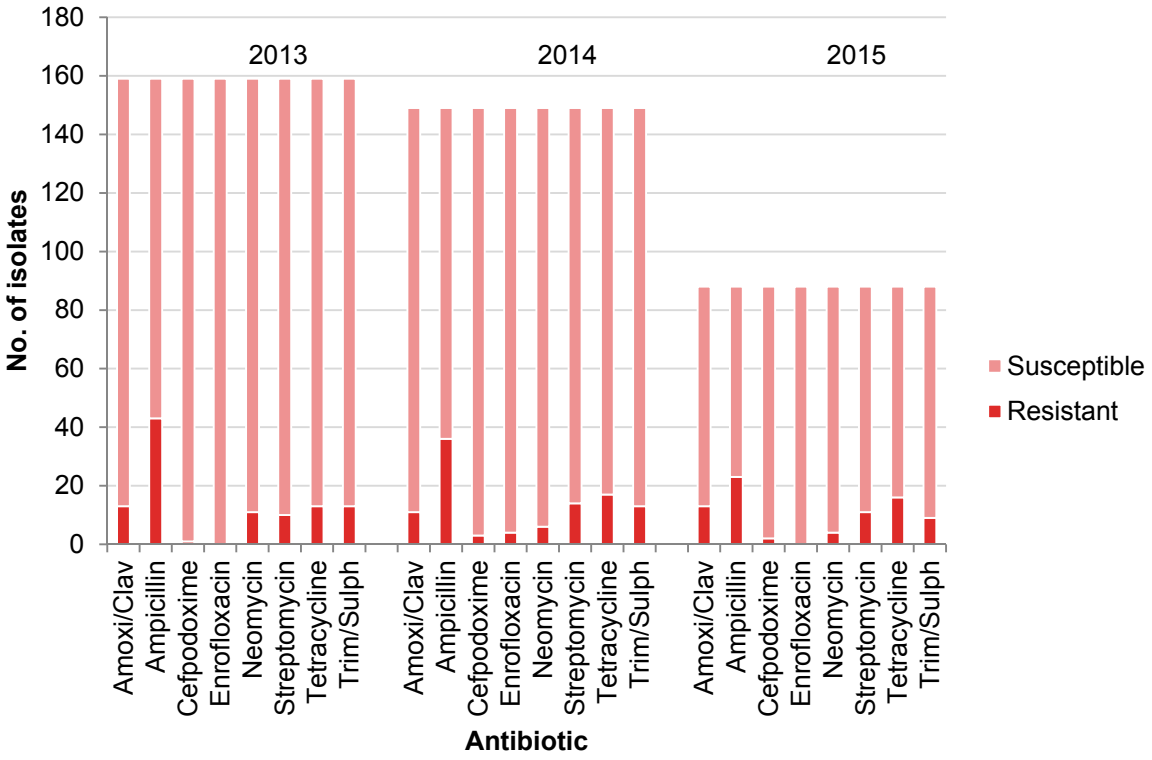
Results

Where more than 20 isolates of any pathogen were recovered in any given year the results are presented graphically in the main body of the report, with additional numerical data available in the annex. Where fewer than 20 isolates were recovered, results are presented in the annex only.

Mastitis Pathogens

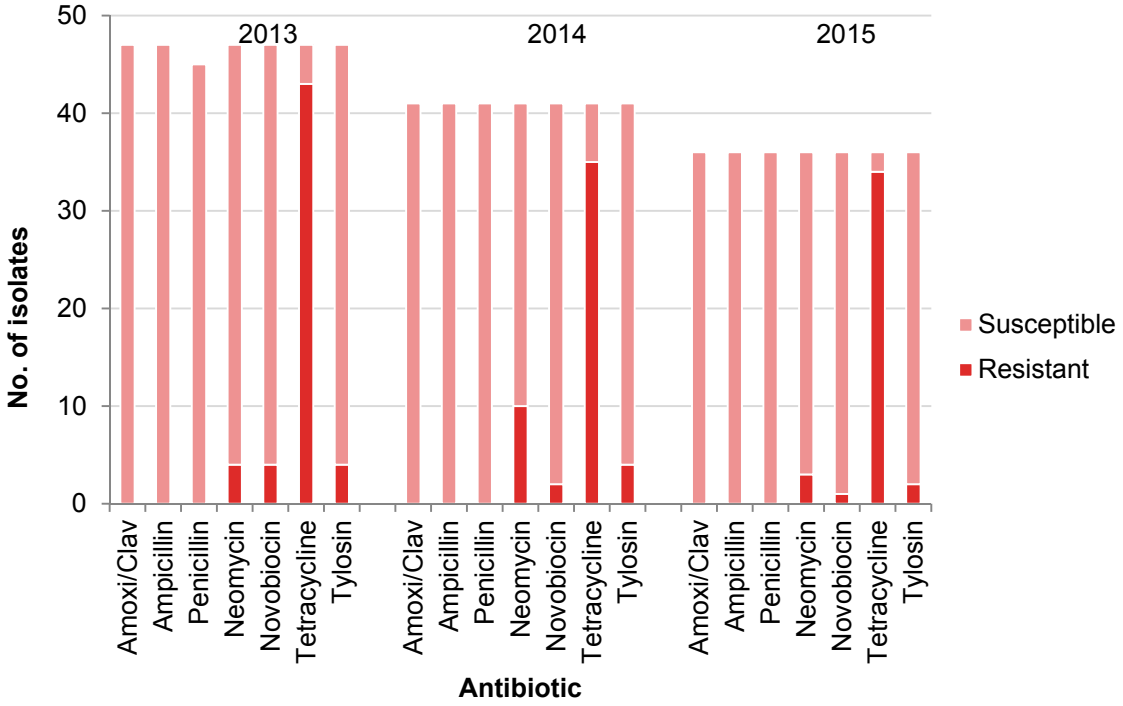
Escherichia coli*: E. coli* and other coliforms are one of the three main causes of bovine mastitis (resistance in *E. coli* isolates not associated with mastitis is reported in Table 4.2). Most strains originate from the immediate environment of the cow and it is thought that no special virulence factors 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 4.1: Resistance and susceptibility (interpreted using BSAC CBPs) of *E. coli* isolates from mastitis infections of cattle, 2013-2015



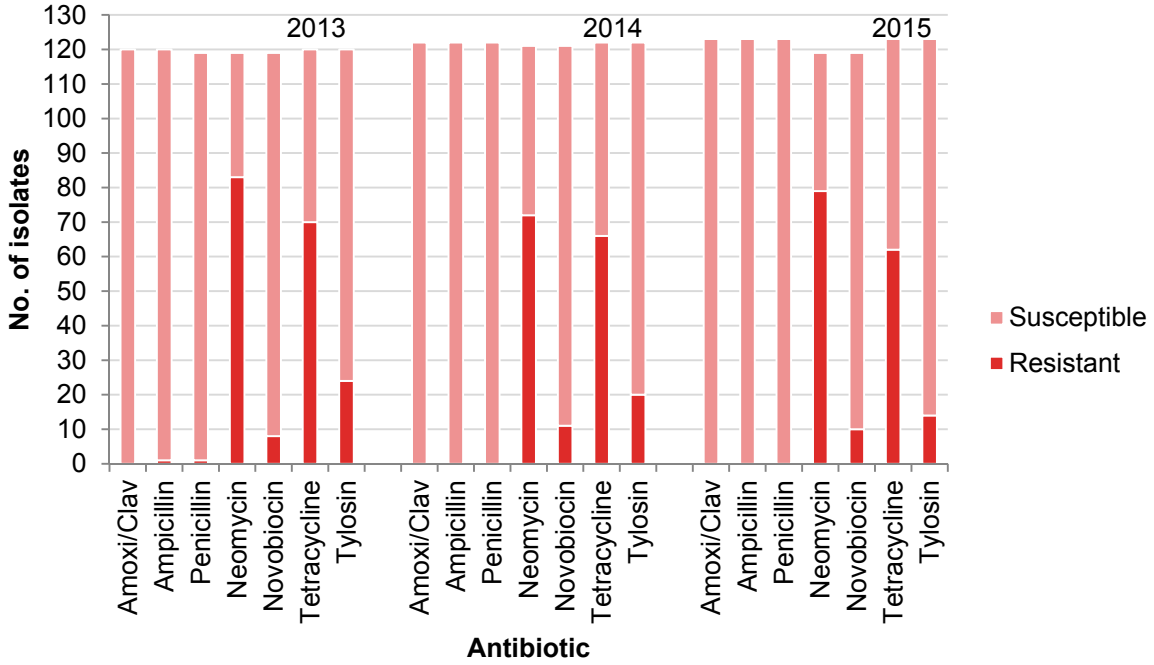
Streptococcus dysgalactiae: *S. dysgalactiae* is a Lancefield Group C streptococcus and a commensal of the mucous membranes of cattle. It is a cause of mastitis and occasionally other diseases in other livestock species. It is not considered a zoonosis, because Group C streptococci that can cause disease in humans constitute a separate population.

Figure 4.2: Resistance and susceptibility (interpreted using BSAC CBPs) of *S. dysgalactiae* isolates from mastitis infections of cattle, 2013-2015



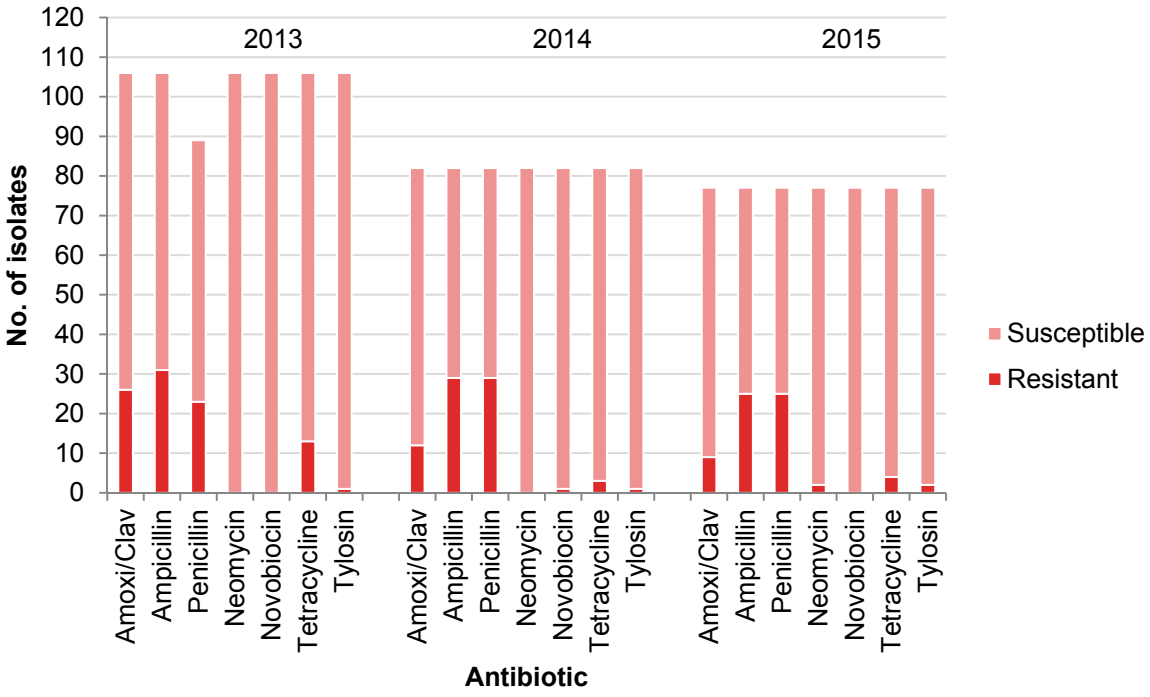
Streptococcus uberis: *S. uberis* is widely distributed in the environment and a normal commensal resident of the bovine vagina, tonsil and skin. It is a common cause of mastitis and not regarded as zoonotic.

Figure 4.3: Resistance and susceptibility (interpreted using BSAC CBPs) of *S. uberis* isolates from mastitis infections of cattle, 2013-2015



Staphylococcus aureus: *S. aureus* is normally resident on the skin and mucous membranes of cattle and is a common cause of mastitis. It is not generally regarded as a common cause of zoonotic infections, and although both MRSA and a recently-described variant form of MRSA have been detected in cattle (Vanderhaeghen *et al*. 2010, García-Álvarez *et al*. 2011), the possible role of cattle as a source of human infection has not been well-defined. Other strains of *S. aureus* are, for the most part, generally specific to a host-species. *S. aureus* isolates from non-mastitis cases are detailed in Annex 15.

Figure 4.4: Resistance and susceptibility (interpreted using BSAC CBPs) of *S. aureus* isolates from mastitis infections of cattle, 2013-2015



The most frequently isolated organisms from milk samples sent to APHA in 2015 were *Streptococcus uberis, E. coli* and *Staphylococcus aureus*. In general, streptococci are naturally resistant to aminoglycosides, therefore the finding that 79/119 (60%) of *S. uberis* isolates were resistant to neomycin is not unexpected. Tetracycline resistance was also common with 62/123 (50%) isolates being resistant. None of the authorised intramammary preparations contain tetracycline antibiotics so this high level of resistance is not likely not to be attributable to use of these preparations. *S. uberis* is ubiquitous in the environment and can exist in the gastrointestinal tract and on the skin of bovines. Without knowledge of the clinical history of each case, it is not possible to assess whether the tetracycline resistance may have been selected for by efforts to treat mastitis with systemic antibiotics, or as a result of the bacteria being exposed to systemic or oral antibiotics used in the treatment of other conditions.

Penicillin resistance in *Staphylococcus aureus* from mastitis cases is not a novel finding in the UK. However the finding that 25/77 (32%) of isolates were resistant to penicillin and amoxicillin and 12% were resistant to amoxicillin/clavulanic acid in 2015 is significant as many intramammary preparations contain these antibiotics. This highlights the need for regular and accurate culture and

sensitivity testing, as in one third of cases empirical treatment with penicillin may have resulted in treatment failure and prolonged disease.

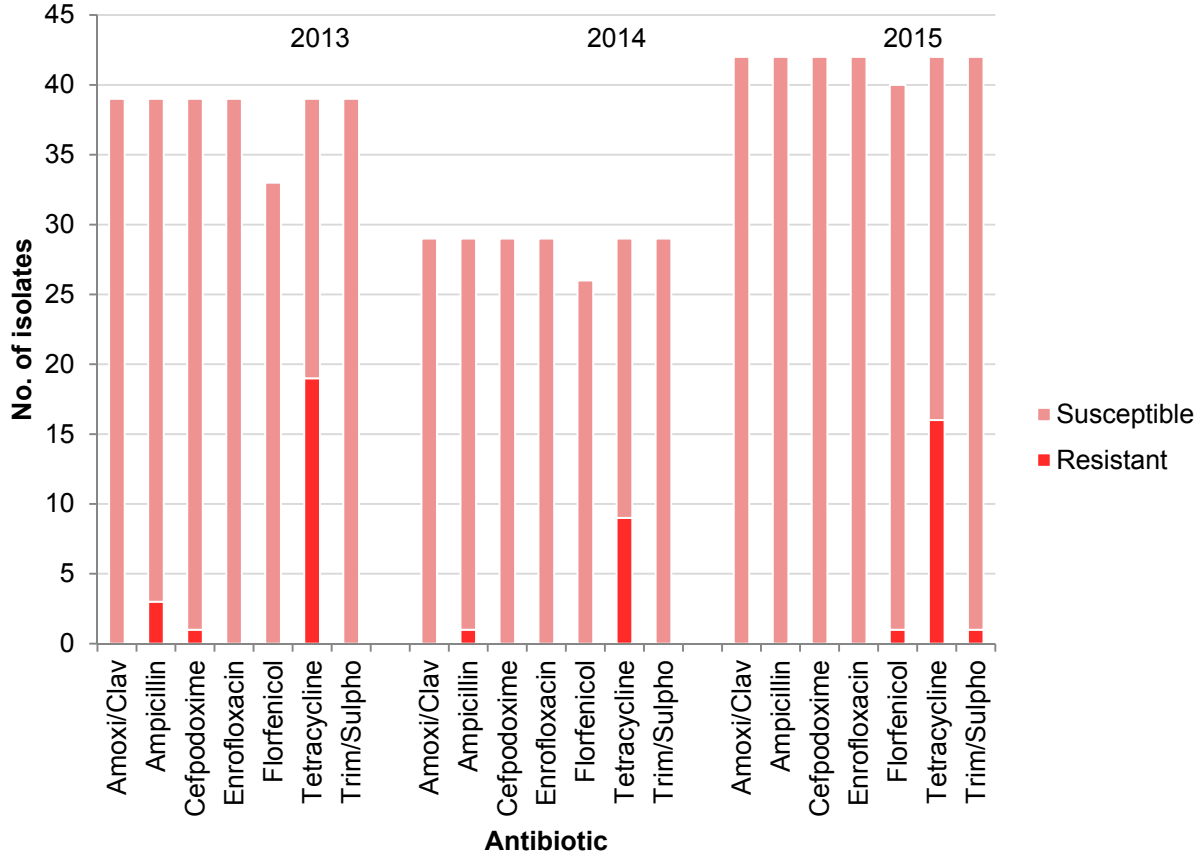
Mastitis is complex and the patterns of resistance observed vary with time and between farms. These data are aggregated at a national level and therefore have a limited ability to inform treatment protocols, but they do highlight that acquired resistance does occur in England and Wales and this should be considered when vets and farmers develop mastitis control programs for individual farms.

Respiratory Pathogens

Cattle

Pasteurella multocida is a causative agent of respiratory or systemic disease in cattle. Toxigenic strains are responsible for the development of atrophic rhinitis in pigs and 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.

Figure 4.5: Resistance and susceptibility (interpreted using BSAC CBPs) of *P. multocida* isolates from respiratory infections of cattle, 2013-2015

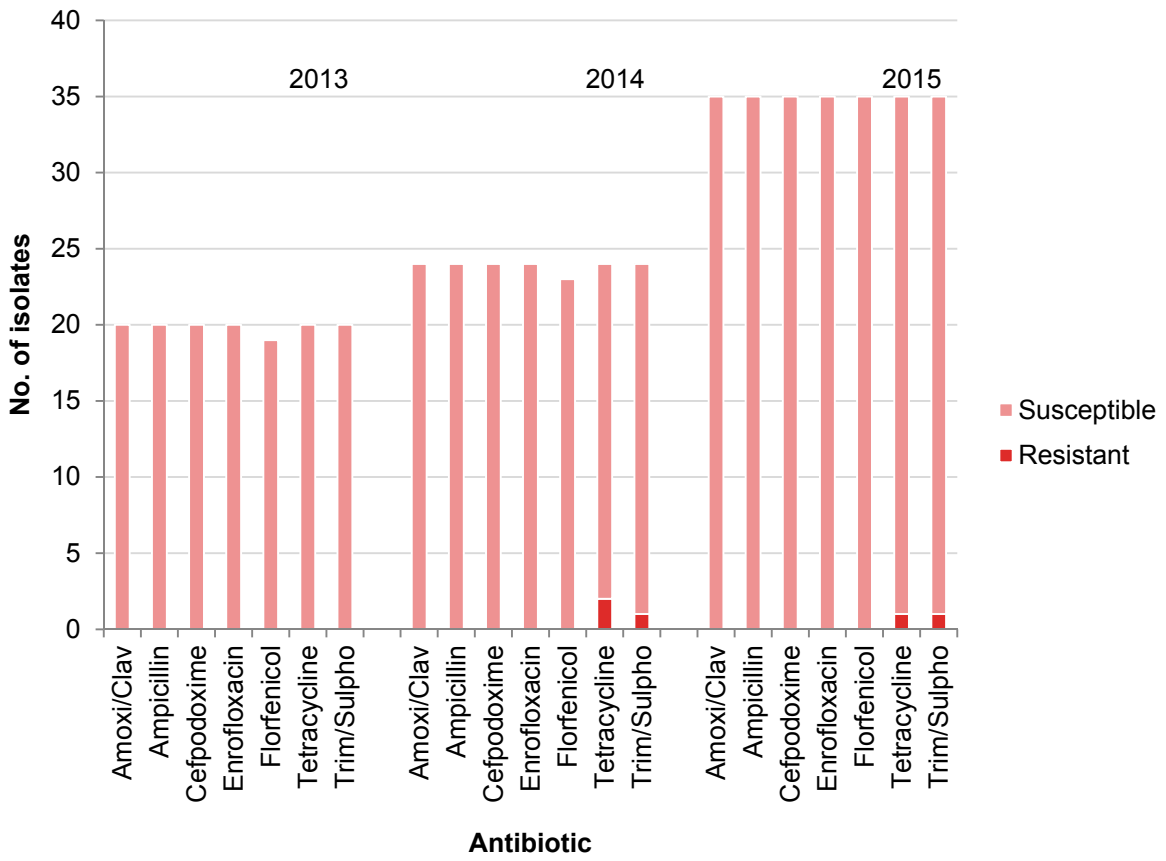


It is noteworthy that resistance to florfenicol was identified in 1/40 (3%) isolates of *P. multocida* from cattle in 2015 as it had not been identified in 2013 or 2014. Florfenicol is effective for treating a number of pathogens which contribute to bovine respiratory disease complex; therefore it is a valuable option for the treatment of the bacterial component of respiratory disease in cattle. At present it is not possible to estimate the prevalence or significance of this resistance in the bovine population. However, this finding, combined with the finding of quite high levels of tetracycline resistance, demonstrates that resistance is present and reinforces the need to reduce incidence of respiratory disease in cattle through measures such as improving biosecurity, optimising husbandry, and vaccination.

Sheep

Mannheimia haemolytica is a common cause of respiratory disease in the UK. There is carriage in the upper respiratory tract in healthy animals and ovine *Mannheimia* strains can also occasionally cause bovine mastitis. Further data on less frequently isolated ovine respiratory pathogens such as *Bibersteinia trehalosi* and *Trueperella pyogenes* can be found in Annex 12 and Annex 14.

Figure 4.6: Resistance and susceptibility (interpreted using BSAC CBPs) of *M. haemolytica* isolates from respiratory infections of sheep, 2013-2015



The number of *M. haemolytica* isolates cultured from sheep was low and therefore any trends need to be interpreted with caution. However, antibiotic resistance appears to be rare in these isolates and may reflect the suspected low use of antibiotics in sheep.

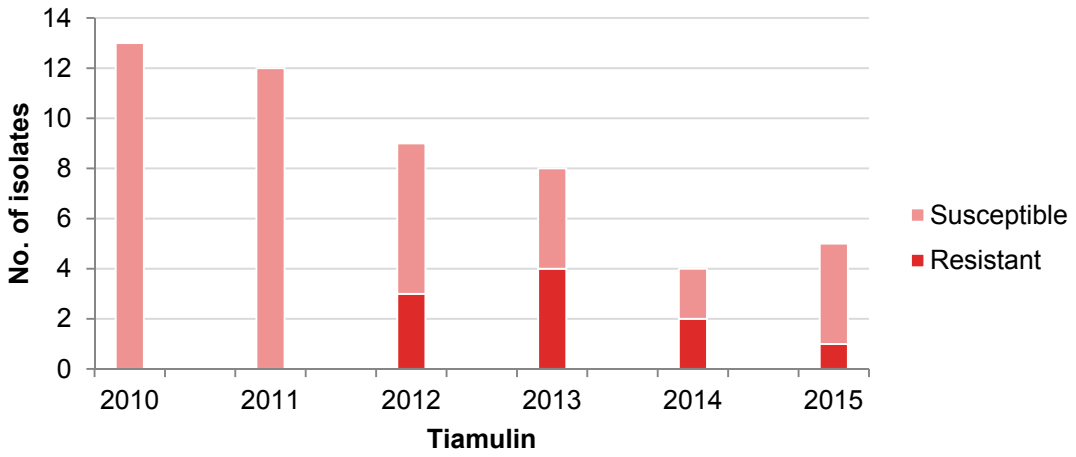
Other Animal Pathogens

Brachyspira hyodysenteriae: *B. hyodysenteriae* is the causative organism of swine dysentery, an enteric disease of pigs, resulting in serious ill-thrift in its chronic form. A limited range of antibiotics is available for the treatment of swine dysentery and, since resistance arises through mutation, reliance on on-going medication without addressing other aspects of disease control, such as hygiene and herd husbandry carries the attendant risk that mutational resistance may arise.

Tiamulin is an important antibiotic used for the treatment of swine dysentery. Tiamulin-resistant isolates are of particular concern as they 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. In such instances, the only practical option may eventually be to depopulate herds, with serious economic implications for the farmer. However, tiamulin-resistance in *B. hyodysenteriae* in conjunction with resistance to other available therapeutic compounds remains extremely uncommon. It should be noted that *B. hyodysenteriae* is not a zoonotic pathogen and tiamulin is not used to treat humans, therefore concerns about resistance in this pathogen are centred on animal health and welfare.

The susceptibility of selected *B. hyodysenteriae* isolates tested between 2010 and 2015 is shown in Figure 4.7; 51 isolates were recovered and tested during this period. This includes some “repeat” isolates (i.e. isolates recovered from the same farm premises over a period of time) and two isolates from 2013 taken from the same premises which had a tiamulin MIC>8mg/L. A breakpoint of resistance >4 mg/L tiamulin was used (Rønne and Szancer, 1990), which has also recently been quoted in a Dutch study of swine dysentery in pigs (Duinhof *et al*., 2008).

Figure 4.7: Resistance and susceptibility of *Brachyspira hyodysenteriae* isolates from pigs in England and Wales to tiamulin, 2010-2015

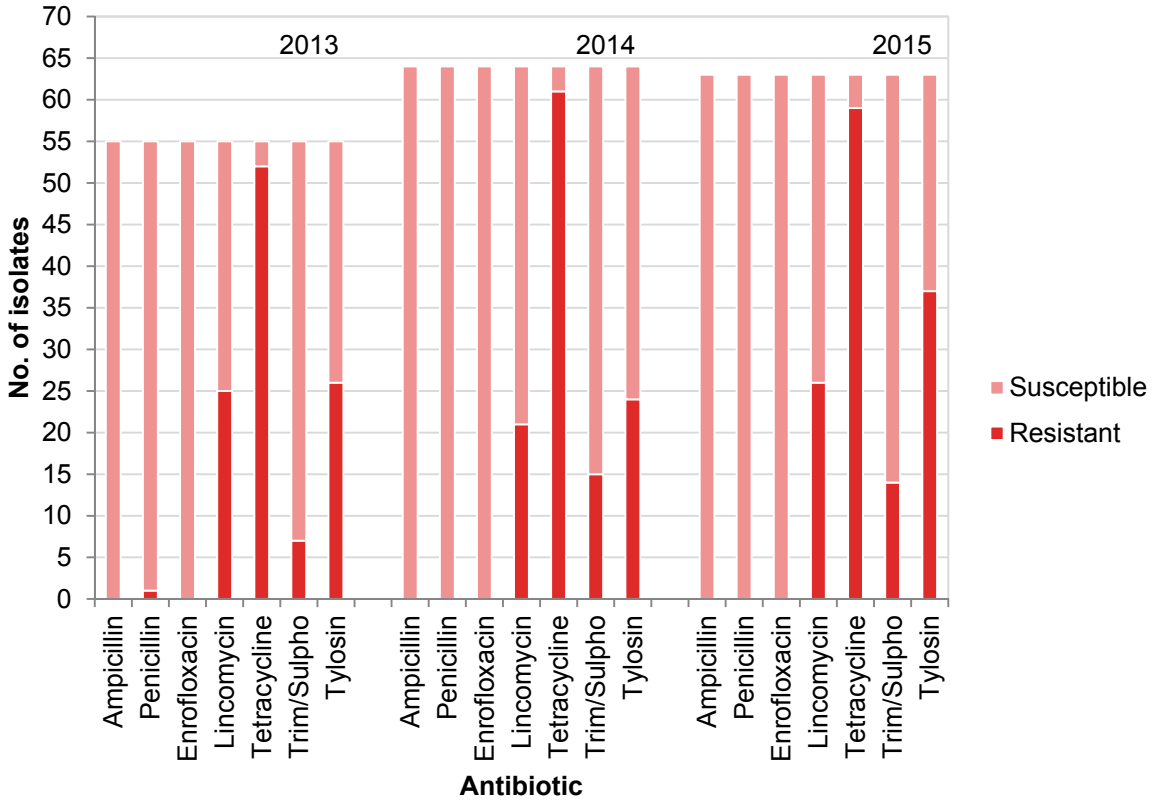


In 2015, one of five *B. hyodysenteriae* isolates was resistant to tiamulin (Fig. 4.7). Because of the importance of this disease and the significance of resistance to tiamulin, all available isolates are tested for tiamulin susceptibility each year.

Zoonotic Pathogens

Streptococcus suis: *S suis* is a pathogen that can cause pneumonia, meningitis and arthritis in pigs. It can also rarely infect man. Between 2013 and 2015, 182 isolates were recovered from pigs via clinical surveillance activities (see Annex 15 for further information).

Figure 4.8: Resistance and susceptibility (interpreted using BSAC human clinical breakpoints) of *S. suis* isolates from pigs, 2013-2015



No resistance to ampicillin or penicillin was observed in *S. suis* in 2015. These antibiotics are often recommended for treatment of *S. suis,* so the absence of resistance is favourable. The findings suggest that treatment with highest priority critically important antibiotics were rarely indicated in these cases.

Each year a large proportion of *S. suis* isolates were resistant to tetracycline with 59/63 (94%) resistant in 2015, however tetracycline is not commonly used for the treatment of this disease. *S. suis* can reside in the tonsillar crypts of asymptomatic pigs, therefore the resistance observed may be a result of exposure following oral administration of tetracycline for the treatment of a different condition.

Livestock Associated-MRSA

LA-MRSA was detected for the first time in 2005, and has since spread worldwide, being detected in the UK for the first time in 2013.

LA-MRSA is different from other types of MRSA, such as hospital or community associated strains which are more frequently found in humans. Anyone who has contact with colonised livestock can become colonised with LA-MRSA but prolonged colonisation is more likely in people who have regular, prolonged contact with colonised animals. LA-MRSA usually lives in the nose or on skin but if it is able to get into the body e.g. via a wound it can cause an infection. Usually this is a local skin infection, but occasionally it can cause diseases such as pneumonia or blood stream infections.

Further information for people who work with livestock is available at https://www.gov.uk/government/publications/la-mrsa-information-for-people-who-work-with-livestock.

A summary of all findings identified by UK government veterinary laboratories is provided in Table 4.1. These reports should not be interpreted as a prediction of prevalence in the animal population, as samples have been collected through differing methods of passive surveillance in animals which are affected with clinical disease. Results may therefore not be representative of the wider, healthy population.

Table 4.1: Findings of LA-MRSA in the UK by government laboratories, 2013-2015

Country of isolation	Year	Clonal complex	Animal species	Source
England & Wales	2013	CC398	Poultry	Clinical investigation
Northern Ireland	2014	CC398	Pig	Clinical investigation
England & Wales	2014	CC398	Pig	Clinical investigation
England & Wales	2015	CC398	Pig	Research project
Northern Ireland	2015	CC30	Pig	Clinical investigation
Northern Ireland	2015	CC398	Dairy cattle	Clinical investigation
Northern Ireland	2015	CC398	Pig	Clinical investigation
Northern Ireland	2015	CC398	Pig	Clinical investigation

CC398 is the most common LA-MRSA CC group isolated from food-producing animal populations in the UK. All isolates are whole genome sequenced and shared with Public Health England (PHE) to investigate any possible associations with infections in humans.

Data for all *Staphylococcus aureus* isolated from clinical investigations in livestock can be found in Annex 15.

Escherichia coli

E. coli is an important ubiquitous bacterium with a zoonotic potential. *E. coli* can, however, occur as a commensal organism in animals and humans, and has the capacity to function as a reservoir of transferable resistance determinants.

This section of the report includes all isolates of *E. coli* and coliform bacteria presumptively identified as *E. coli* through clinical surveillance activities, with the exception of isolates recovered from milk which are included in a previous section on mastitis organisms.

The majority of isolates reported in this section were recovered from faeces or intestinal contents, and includes both pathogenic and commensal strains. Results have been collated for the major food-producing animals (Table 4.2), and resistance data analysed to animal species and age category level (Fig.4.9 - 4.15).

Data from England and Wales are presented in the main body of the report. Data for Scotland and Northern Ireland are presented in Annex 16.

Table 4.2: Resistance in all *Escherichia coli* isolates from cattle, pigs, sheep, broilers and turkeys (all ages, combined) from 2013-2015

Antibiotic	No. of isolates resistant / No. of isolates tested (% resistant)		
	2013	2014	2015
Amikacin	4/856 (0.5%)	2/590 (0.3%)	3/524 (0.6%)
Amoxi/Clav	447/1296 (34.5%)	314/1045 (30%)	282/1034 (27.3%)
Ampicillin	892/1400 (63.7%)	733/1144 (64.1%)	713/1101 (64.8%)
Apramycin	85/1360 (6.3%)	73/1118 (6.5%)	60/1073 (5.6%)
Cefotaxime	98/857 (11.4%)	80/593 (13.5%)	49/526 (9.3%)
Cefpodoxime	27/434 (6.2%)	19/481 (4%)	34/474 (7.2%)
Ceftazidime	53/857 (6.2%)	44/593 (7.4%)	34/526 (6.5%)
Chloramphenicol	440/856 (51.4%)	298/590 (50.5%)	244/524 (46.6%)
Doxycycline	86/371 (23.2%)	157/452 (34.7%)	132/451 (29.3%)
Enrofloxacin	114/1400 (8.1%)	93/1144 (8.1%)	118/1101 (10.7%)
Florfenicol	295/969 (30.4%)	209/764 (27.4%)	174/709 (24.5%)
Neomycin	398/1282 (31%)	287/1049 (27.4%)	266/1030 (25.8%)
Spectinomycin	565/1360 (41.5%)	441/1118 (39.4%)	462/1073 (43.1%)
Streptomycin	556/933 (59.6%)	442/742 (59.6%)	443/685 (64.7%)
Tetracycline	932/1400 (66.6%)	779/1144 (68.1%)	708/1101 (64.3%)
Trimetho/Sulpho	508/1400 (36.3%)	442/1144 (38.6%)	420/1101 (38.1%)

Note: A table detailing the full breakdown of proportion of resistance to all antibiotics in all livestock species can be found in Annex 16.

Fluoroquinolones and 3rd/4th generation cephalosporins are considered to be highest priority critically important antibiotics (HP-CIA) for use in people (for more detailed discussion of this classification, please refer to Chapter 1). In general, the level of resistance to these antibiotics in *E. coli* isolates was low.

At the end of 2015 the EMA's Antimicrobials Expert Group (AMEG) advised that colistin should also be considered as a HP-CIA. All clinical isolates are tested for resistance using a disc diffusion method; however colistin is a very large molecule which means that conventional disc diffusion is an unreliable method for testing colistin susceptibility. Following the recommendation by AMEG, APHA implemented a pre-diffusion method to test for colistin resistance. This additional step was adopted as standard in 2016 but was not frequently used in 2015; therefore results of colistin susceptibility testing in 2015 are not reported.

Resistance to the third generation cephalosporins (cefotaxime, ceftazidime or cefpodoxime) detected in *E. coli*/presumptive *E. coli* in animals will include resistance mediated by both ESBL and AmpC resistance mechanisms. The higher prevalence of resistance to cefotaxime versus ceftazidime observed, for example, in neonatal calves (Figure 4.10), may reflect the occurrence of ESBL enzymes which are cefotaximases, rather than ceftazidimases.

The relatively high frequency at which *E. coli* resistant to ampicillin are recovered from young calves may reflect the use of dry cow intra-mammary infusions in the dam and the transfer of residual antibiotics to calves in colostrum, which may then exert a selective pressure on the intestinal bacterial flora of the neonatal calf.

In general, lower levels of resistance to most antibiotics are consistently observed in sheep than in pigs and cattle. Cefotaxime and ceftazidime resistance were detected in neonatal lambs, the former at a slightly higher prevalence. As in calves, this may reflect the occurrence of ESBL enzymes which are cefotaximases, rather than ceftazidimases.

Plasmid mediated colistin resistance

In November 2015, the first report was published describing transferable resistance to colistin (Liu et al., 2015), mediated by the gene *mcr-1*, a key distinction to the known intrinsic resistance Colistin is a polymyxin antibiotic which has been used for many years to treat enteric infections (especially *E. coli* infections) in farm animals in many European countries. In the UK however, colistin has only been authorised for the treatment of animals since 2004. The emergence of resistant organisms in human medicine which are resistant to most or all other treatment options has meant that colistin, despite its toxicity when administered systemically, is increasing in importance as one of the antimicrobials of last resort for the treatment of pan-resistant Enterobacteriaceae (*Klebsiella* spp., *E. coli*), *Pseudomonas* spp. and *Acinetobacter* spp. infections in man. Human patients can be exposed to resistant bacteria from a number of different sources, including for example those occurring in healthcare settings, in international travellers, in domestically-produced and imported foodstuffs as well as in animals. Although resistant bacterial organisms can originate from a number of different sources, limiting the occurrence and diffusion of colistin resistance in bacteria in the animal population in the UK is desirable to minimise any exposure which might arise from that particular source.

A pig herd, in which phenotypic colistin resistance in *E. coli* had been detected, was already under active investigation in November 2015. This herd had been identified through scanning surveillance. The presence of *mcr-1* conferring colistin resistance was subsequently confirmed in *E. coli* and *Salmonella* Typhimurium var. Copenhagen from the pig herd (Anjum et al. 2016).

The occurrence of *mcr-1* within the UK pig population was subsequently assessed by screening 163 archived *E. coli* isolates from veterinary diagnostic submissions from pigs from England and Wales for the presence of *mcr-1*. The isolates originated from 105 different pig herds, collected in 2015/early 2016 and isolates from 2/105 different herds (1.9%) were positive for *mcr-1*. [This figure of two positive herds includes the herd referred to in the paragraph above].

Archived caecal samples from pigs, which had been stored frozen, were also examined for colistin resistance using a selective culture method. This involved culture in buffered peptone water and then plating onto MacConkey agar containing colistin and allowed only those isolates resistant to colistin (at the level of inclusion) to grow. The method therefore screened large numbers of different *E. coli* present in each caecal sample for resistance to colistin. The caecal samples each originated from different pig herds, which had been selected to ensure that they were from herds representative of the majority of pigs slaughtered in Great Britain. The transferable colistin resistance gene *mcr-1* was detected in 2/313 pig caecal samples from different pig herds or 0.6%. These caecal samples had been anonymised as part of the abattoir surveillance protocol, so it is not known if these herds were related to those detected through surveillance of veterinary diagnostic submissions referred to in the paragraph above (Duggett et al 2016).

We now know that this type of transferable colistin resistance has been around for much longer than was first thought following studies in other countries, with reports of detection in archived bacteria from animals dating to 2005 in France and to the 1980s in China (Schwarz and Johnson, 2016). The European Medicines Agency recently considered the use of colistin in animals in the EU (http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2016/07/WC500211080.pdf); colistin consumption in animals in the UK currently lies below both the target and desirable levels for EU countries.

Cattle

For some livestock species, the age of the animal at the time of sampling can have a large impact on the percentage of resistant isolates detected, with a general trend towards decreasing resistance in adult livestock. Therefore, when interpreting the total resistance data presented in this section of the report, please note that large differences in the levels of resistance observed in the main livestock groups may reflect the differing proportions of the age-classes of animals which have contributed to the figures.

Figure 4.9: Resistance (interpreted using BSAC CBPs) in *E. coli* from cattle (all ages) in 2013, 2014 and 2015

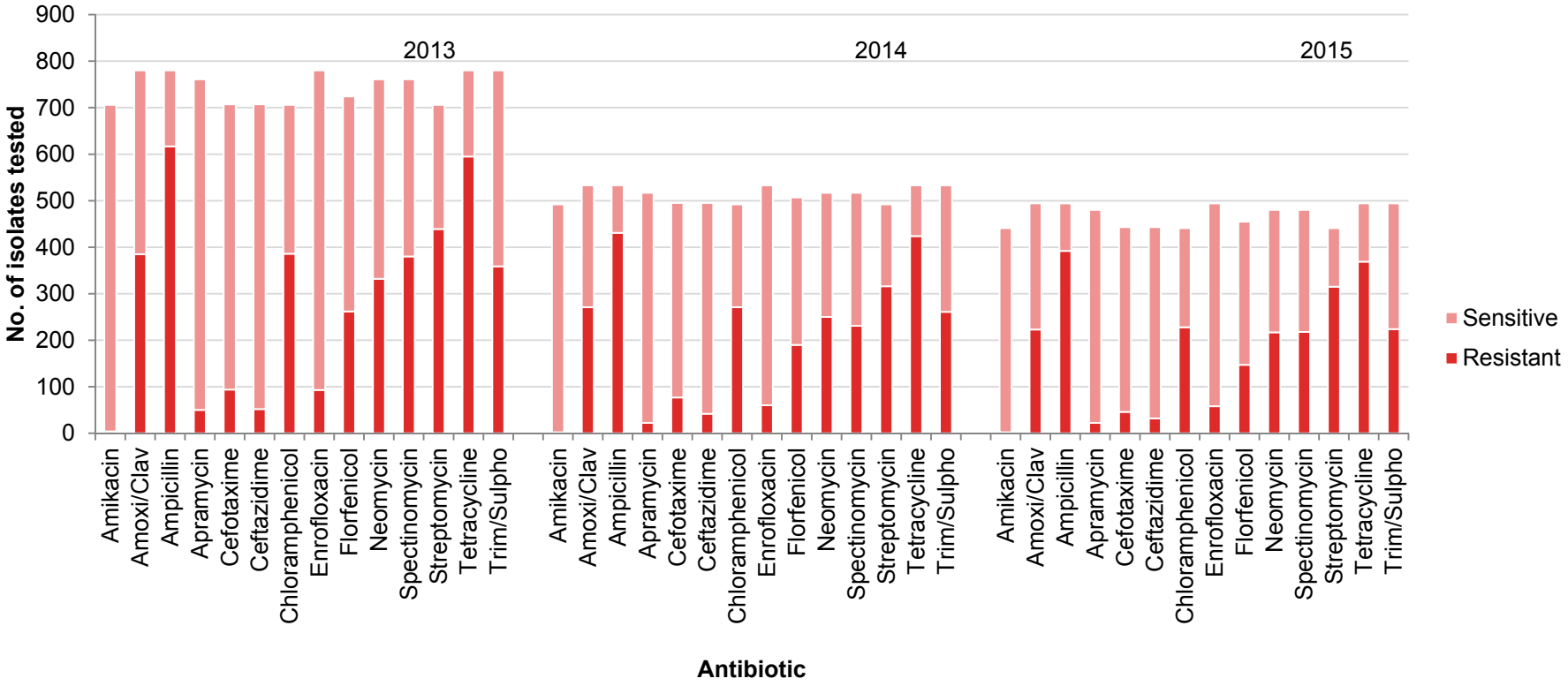
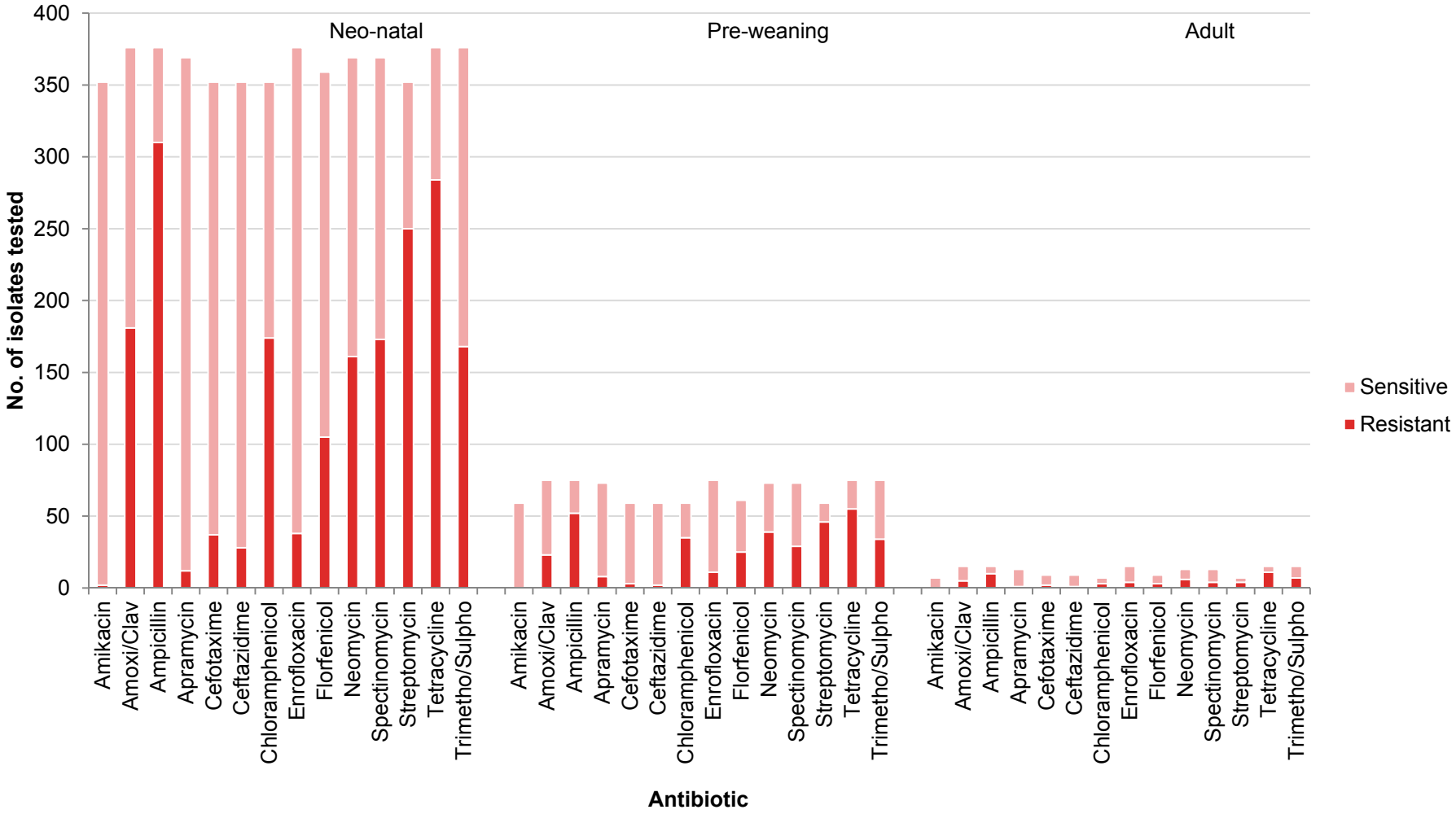


Figure 4.10: Resistance (interpreted using BSAC CBPs) in *E. coli* in 2015 from cattle (by age category)



Pigs

Figure 4.11: Resistance (interpreted using BSAC CBPs) in *E. coli* from pigs (all ages) in 2013, 2014 and 2015

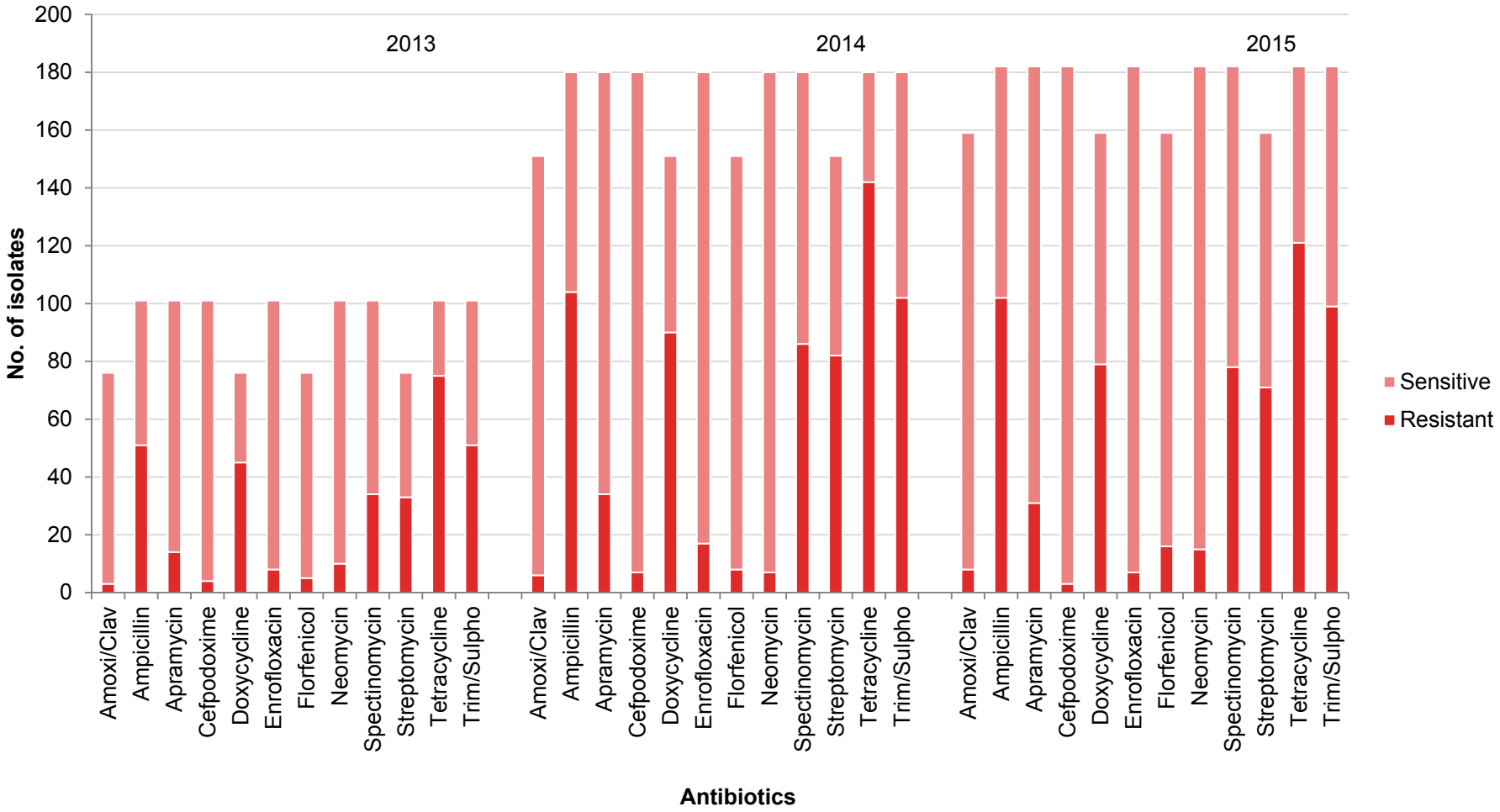


Figure 4.12: Resistance (interpreted using BSAC CBPs) in *E. coli* from pigs in 2015 (by age category) in 2015

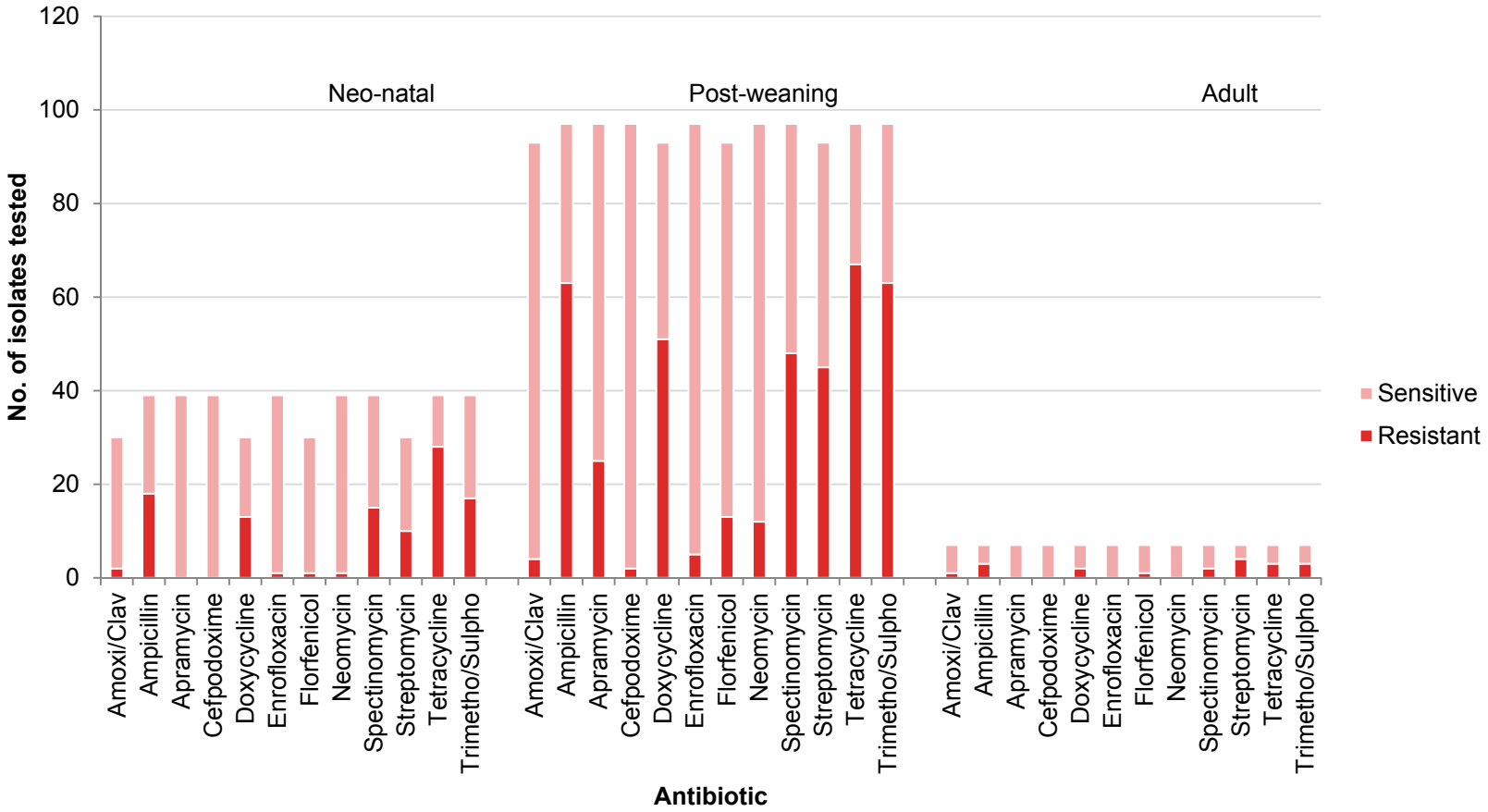


Figure 4.13: Resistance (interpreted using BSAC CBPs) in *E. coli* from sheep (all ages) in 2013, 2014 and 2015

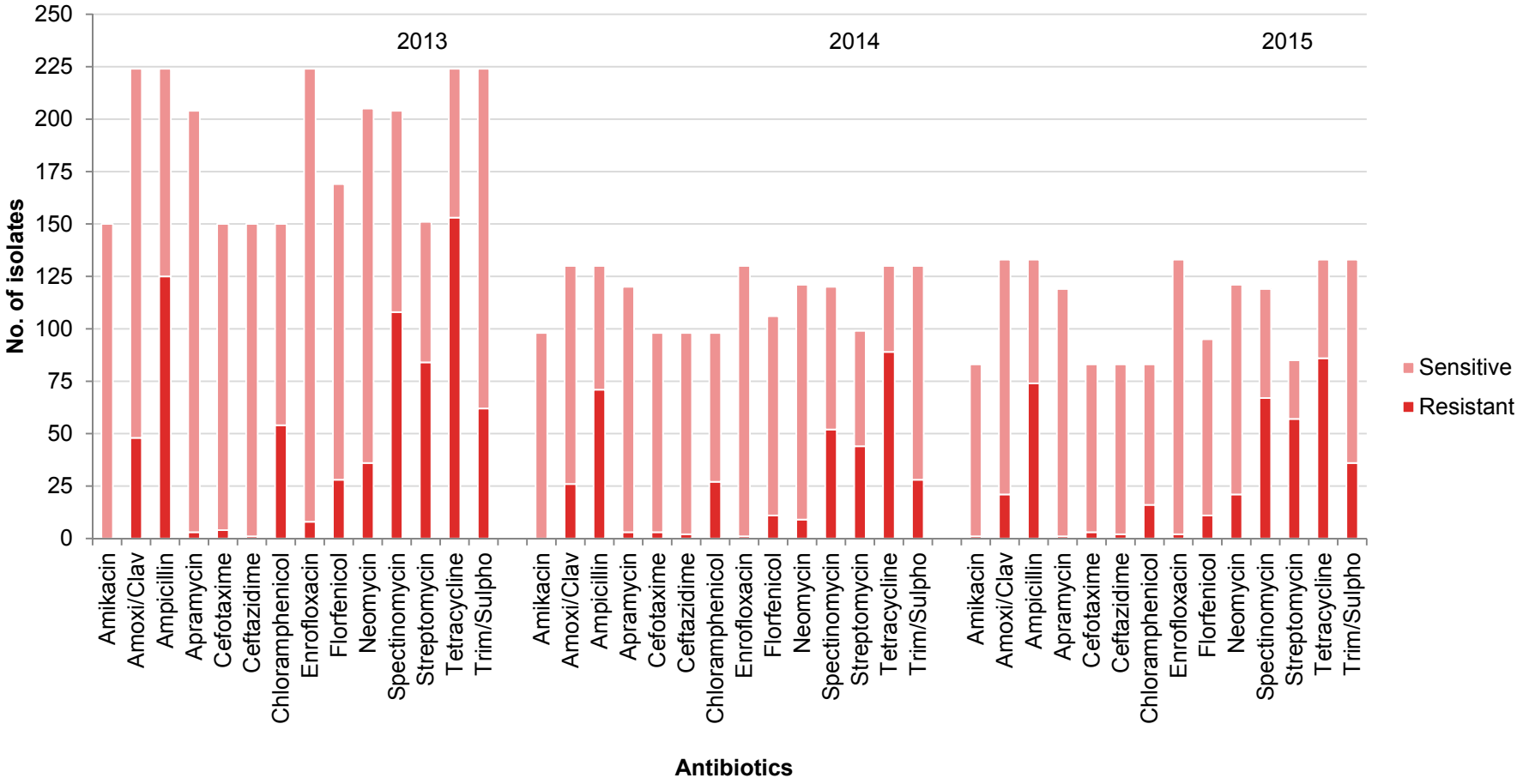


Figure 4.14: Resistance (interpreted using BSAC CBPs) in *E. coli* from sheep in 2015 (by age category)

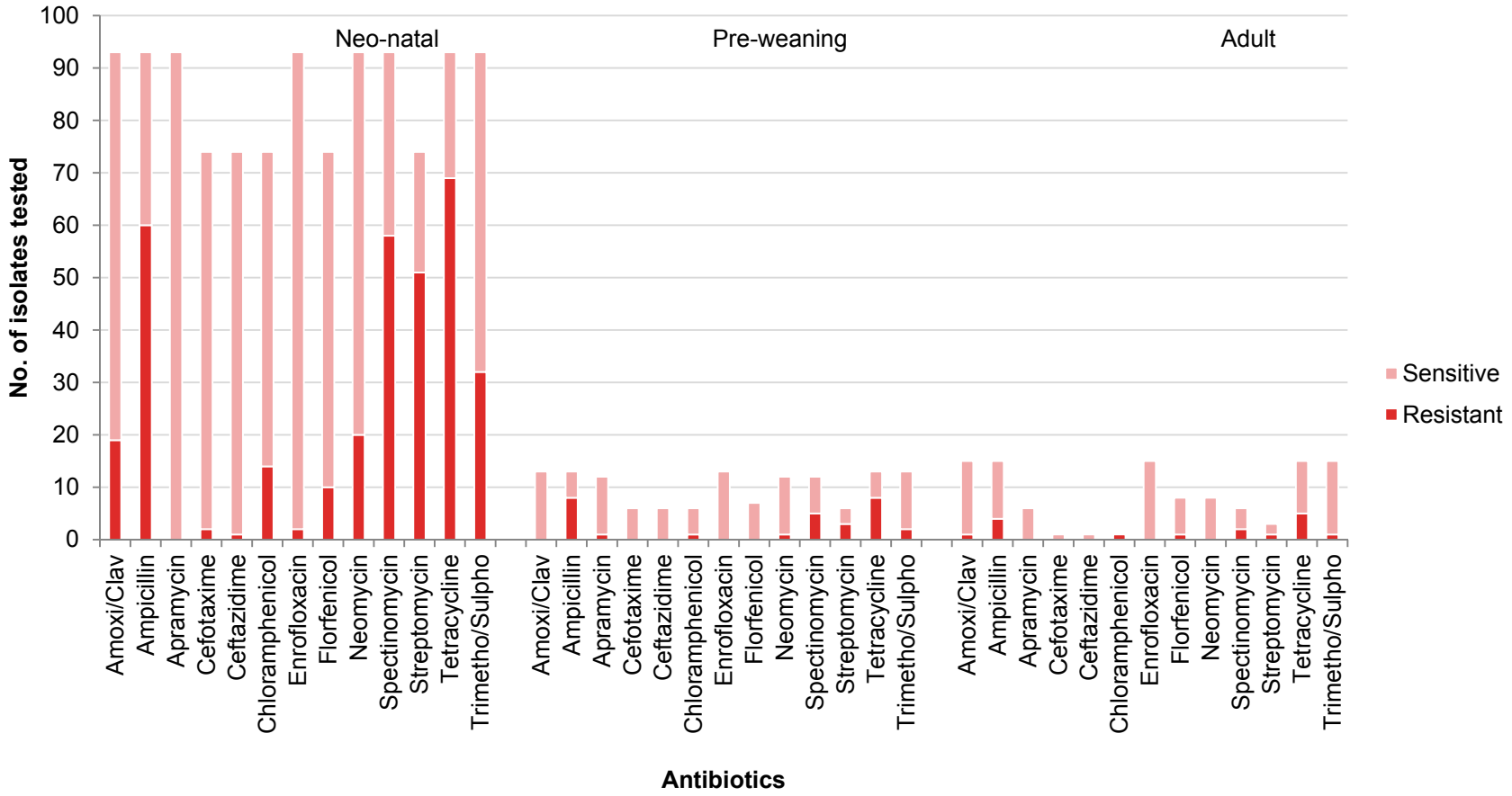
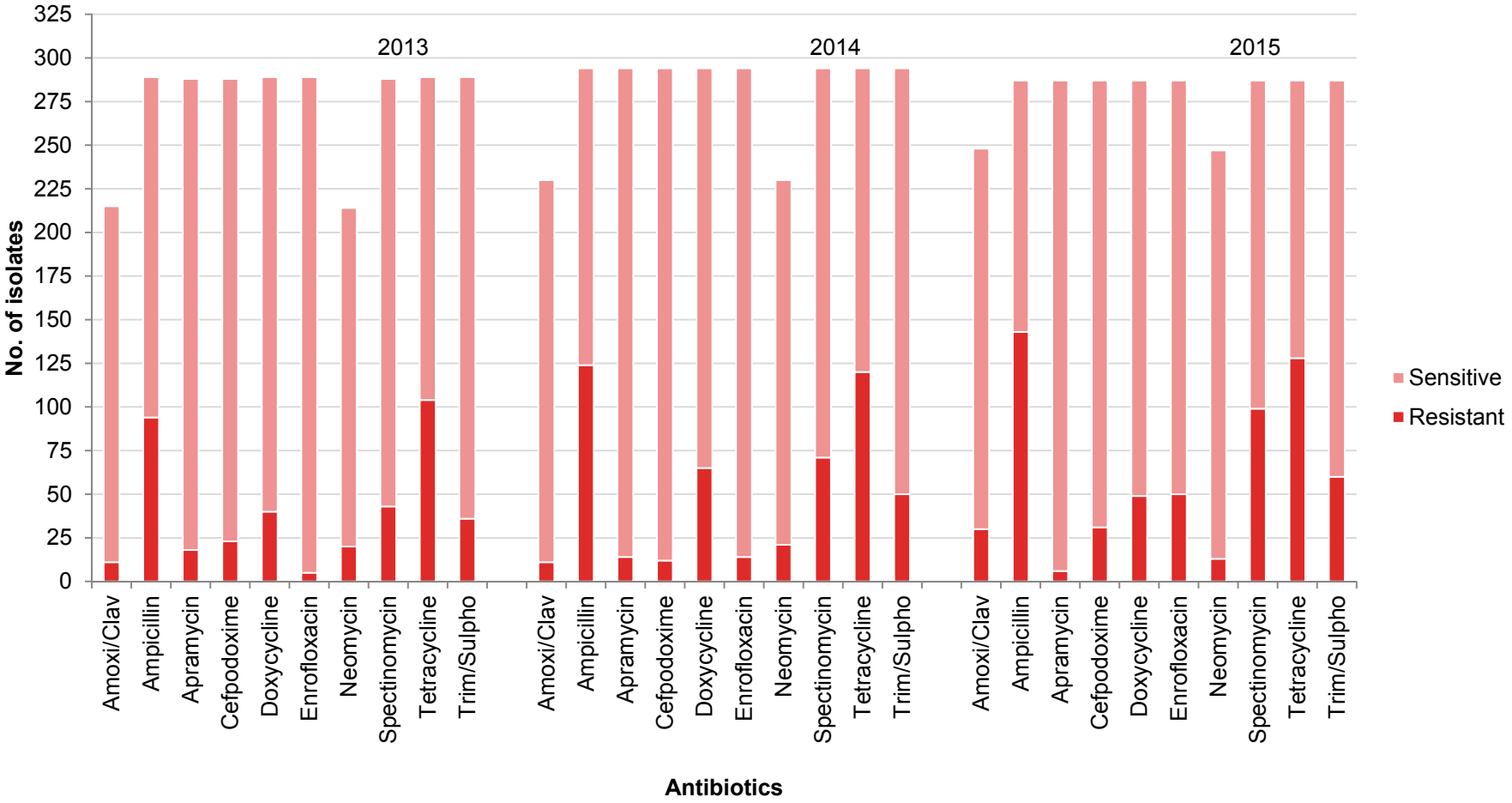


Figure 4.15: Resistance (interpreted using BSAC CBPs) in *E. coli* from chickens in 2013, 2014 and 2015



Salmonella spp.

All *Salmonella* – Summary

This section of the report presents an overview of all the clinical surveillance of *Salmonella* isolates that were tested for resistance in 2013-2015. *Salmonella* is also reportable under the Zoonoses Order 1989, so any laboratory which isolates *Salmonella* from a food producing animal is required to inform APHA and make the isolate available for further testing if requested, and as a result of this the clinical surveillance of *Salmonella* is enhanced. *Salmonella* originating from the National Control Programme for poultry in the UK were not susceptibility tested in 2015 and, as such, the dataset presented below does not include isolates from this source.

Due to the importance of *Salmonella* as a zoonotic pathogen, it is useful to look at the serotype and even phage type of an isolate when investigating potential epidemiological links between animal and human cases. For this reason, individual serotypes are also reported in this section. Considering the findings of this report in relation to *Salmonella*, resistance to third generation cephalosporins and fluoroquinolones is of particular importance, since these antibiotics are most commonly used for the treatment of human salmonellosis, where treatment is required. However it should be noted that most cases of non-typhoidal *Salmonella* infection in humans are non-invasive, limited to the gastro-intestinal tract and do not require antibiotic treatment.

Where resistance to third generation cephalosporins and fluoroquinolones is detected in a food producing animal(s), attempts are made to visit the farms in order to explain the significance of the findings and provide appropriate advice on control. Only 0.9% of all *Salmonella* isolates were resistant to ciprofloxacin and 0.04% were resistant to ceftazidime or cefotaxime in 2015 (detailed below). Ciprofloxacin resistance was not detected in *S*. Typhimurium, one of the serotypes of particular public health importance.

Other noteworthy isolations in 2015 include:

- The isolation of *S*. Kentucky sequence type (ST) 198 with high-level fluoroquinolone resistance (MIC $\geq$ 8mg/L) in a cattle herd in England and Wales. *Salmonella* Kentucky with these characteristics has been widely detected in North Africa and the Middle East, as well as in travellers to those areas, since 2000 and has subsequently been detected in poultry in some European countries. This isolation was the first report of the ST198 strain in livestock in Great Britain.

- *Salmonella* Typhimurium var Copenhagen with transferable colistin resistance (through possession of the *mcr-1* gene) was identified on a pig farm in 2015.

- It should be highlighted that the number of cultures received from any one farm varies enormously, especially from poultry premises. Some poultry companies have a continuous monitoring programme in place and thus large numbers of *Salmonella* isolates may be received. 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 instead the intensity of the monitoring programme on a farm or group of farms. Therefore, to better indicate the prevalence of resistance, only the first isolate of a given serotype or phage definitive type (DT) from each incident has usually been tested.

The *Salmonella* isolates reported in this section have been tested for their *in vitro* sensitivity to 16 antibiotics as defined in Annex 8. The choice of antibiotics, which is reviewed by APHA periodically, is designed to be a core set which are used in veterinary, as well as in human medicine:

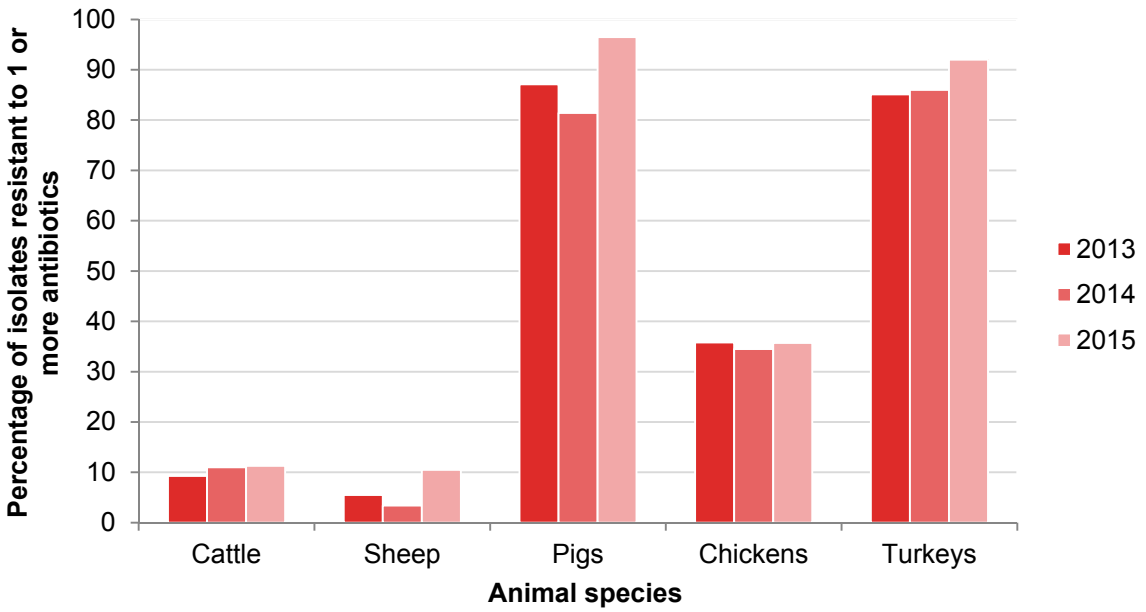
- Amikacin
- Ampicillin
- Amoxicillin/Clavulanic acid
- Apramycin
- Cefotaxime
- Ceftazidime
- Ciprofloxacin
- Chloramphenicol
- Gentamicin
- Furazolidone
- Nalidixic Acid
- Neomycin
- Streptomycin
- Sulphonamide compounds
- Tetracycline
- Trimethoprim/sulphonamide

Data from England & Wales are presented in the main body of the report. Additionally, data for Scotland and Northern Ireland are also presented in Annex 17.

Salmonella – By Animal Species

Figure 4.16 shows the number of *Salmonella* spp. isolates recovered from cattle, sheep, pigs, chickens and turkeys which were resistant to one or more antibiotics.

Figure 4.16: Percentage of *Salmonella* isolates from key animal species which were resistant to one or more antibiotics, 2013-2015



Cattle – Of the 346 *Salmonella* recovered in 2015, the highest levels of resistance were seen to ampicillin (6.6%), streptomycin (5.8%), the sulphonamide compounds (5.2%) and tetracycline (6.1%). In all cases, this is a slight decrease on the levels seen in 2013. In 2015, 11.3% of all *Salmonella* isolates were resistant to one or more antibiotics. This is a slight increase compared to 2014 (11%) and 2013 (9.3%).

Sheep – Of the 57 isolates cultured in 2015, the highest levels of resistance were observed to streptomycin (8.8%), sulphonamide compounds (7%), ampicillin (7%) and tetracycline (7%). In 2015, as in previous years, resistance in *Salmonella* from sheep was generally low, with 10.5% of all isolates resistant to one or more antibiotics tested. This is, however, an increase seen on the levels in 2014 (3.4%) and 2013 (5.5%).

Pigs – Of the 172 isolates recovered in 2015, 96.5% were resistant to one or more antibiotics tested. This is an increase on the levels seen in 2014 (81.4%) and 2013 (87.1%). A large proportion of isolates were resistant to streptomycin (90.1%) and the sulphonamide compounds (90.7%), an increase on the levels seen in 2014 (68.6% and 74.5%, respectively). Other notable resistances were observed to tetracycline (82.6%) and ampicillin (84.9% of isolates).

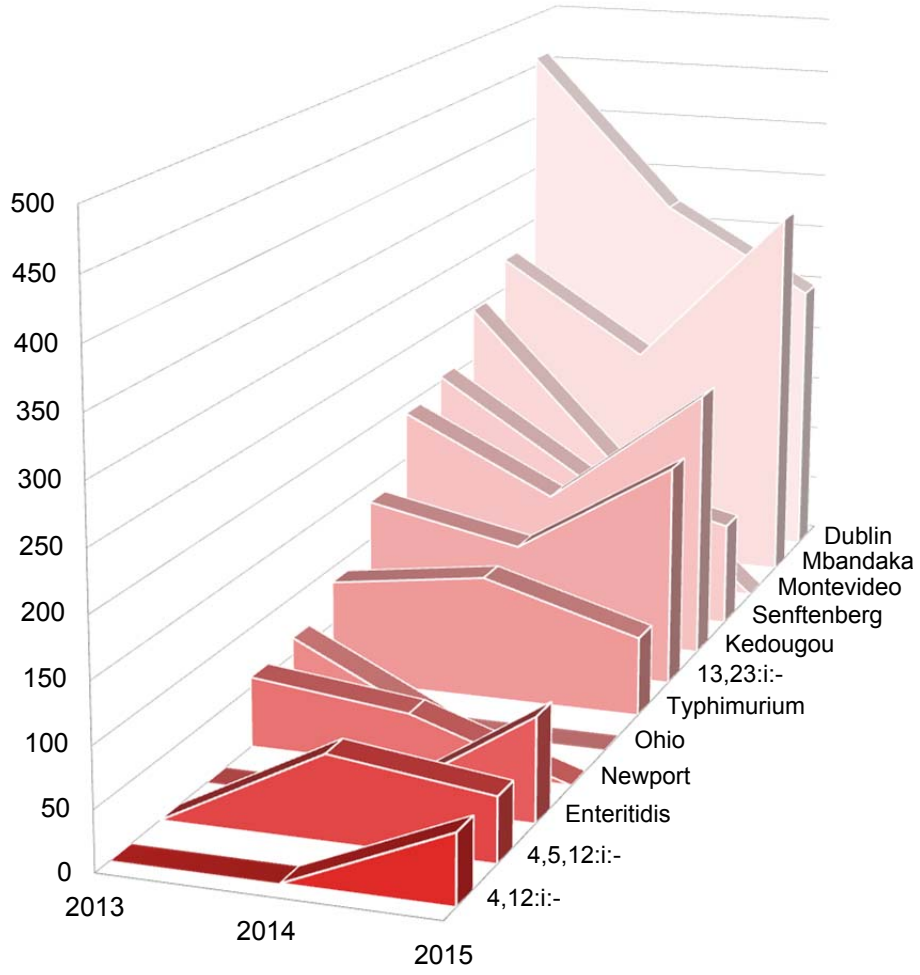
Chickens – Of the 768 isolates tested in 2015, the highest levels of resistance were seen to the sulphonamide compounds (20.6%) and tetracycline (16%), a slight increase on the levels seen in 2014. Resistance to the 3rd generation cephalosporins was absent and resistance to the fluoroquinolone ciprofloxacin was only seen in 0.7% (5/768) of isolates. Gentamicin resistance was observed in 2.3% of isolates, a slight decrease on the levels seen in 2014 (2.9%) and 2013 (3.5%). Of all *Salmonella* from chickens, 35.7% of isolates were resistant to one or more antibiotics tested, which is a similar level to previous years.

Turkeys – As with other livestock species, the highest levels of resistance in *Salmonella* from turkeys in 2015 (n=251) were seen to streptomycin (70.9%), sulphonamide compounds (75.3%) and tetracycline (73.3%), an increase of 5-11% on levels seen in 2014. Ninety-two percent of all isolates were resistant to one or more antibiotics tested, which is an increase on the levels seen in 2014 (86%) and 2013 (85.1%). Of all sources of *Salmonella,* ciprofloxacin resistance was the highest in isolates from turkeys (5.6%) in 2015, although this is a decrease on the levels seen in 2014 (11.2%) and 2013 (7%). Resistance to gentamicin was observed in 0.4% of isolates.

Top ten *Salmonella* serovars isolated between 2013-2015

Some serovars can have characteristic patterns of resistance, so knowledge of the most frequently isolated serovars can be of benefit when considering trends in resistance. The ‘top ten’ serotypes of non-typhoidal *Salmonella* isolates recovered from cattle, pigs, sheep, chickens and turkeys in England & Wales in 2013-2015 are presented in Figure 5.17. *S.* Dublin and *S.* Mbandaka are generally the most consistently isolated serovars year-on-year. Further details on the numbers of isolates can be found in Annex 17.

Figure 4.17: The top ten most commonly isolated *Salmonella* serovars from livestock in 2013-2015



Salmonella Dublin

Of the 226 *Salmonella* Dublin cultures tested during 2015, 94.2% were susceptible to all 16 antibiotics (Table 4.3). The percentage of fully susceptible *S.* Dublin isolates has shown only slight fluctuations over the period 2005-2015 and the majority of isolates remain susceptible. This has been the situation since surveillance began in 1971.

Most *S.* Dublin isolates (92.9%) originated from cattle in 2015, and this was also similar to the situation recorded in previous years. Isolates from species other than cattle in 2015 were all fully susceptible to the panel of 16 antibiotics.

Of the 13 *S*. Dublin isolates showing antibiotic resistance in 2015, ten were only resistant to a single compound in the panel of antibiotics tested (neomycin (4), nalidixic acid (4), ampicillin (1), streptomycin (1).

Table 4.3: Resistance in *Salmonella* Dublin: percentage of resistant isolates in 2013, 2014 and 2015

	Percentage of isolates resistant		
Antibiotic	**2013 (n=393)**	**2014 (n=286)**	**2015 (n=226)**
Ampicillin	0.3	0.7	1.8
Chloramphenicol	0.0	0.0	0.4
Furazolidone	0.0	0.3	0.0
Nalidixic Acid	1.0	0.0	2.2
Neomycin	0.3	0.3	2.2
Streptomycin	1.3	2.4	4.0
Sulphamethoxazole/Trimethoprim	0.0	0.7	0.0
Sulphonamide compounds	0.0	0.7	0.0
Tetracycline	0.0	0.3	0.4

Salmonella Typhimurium

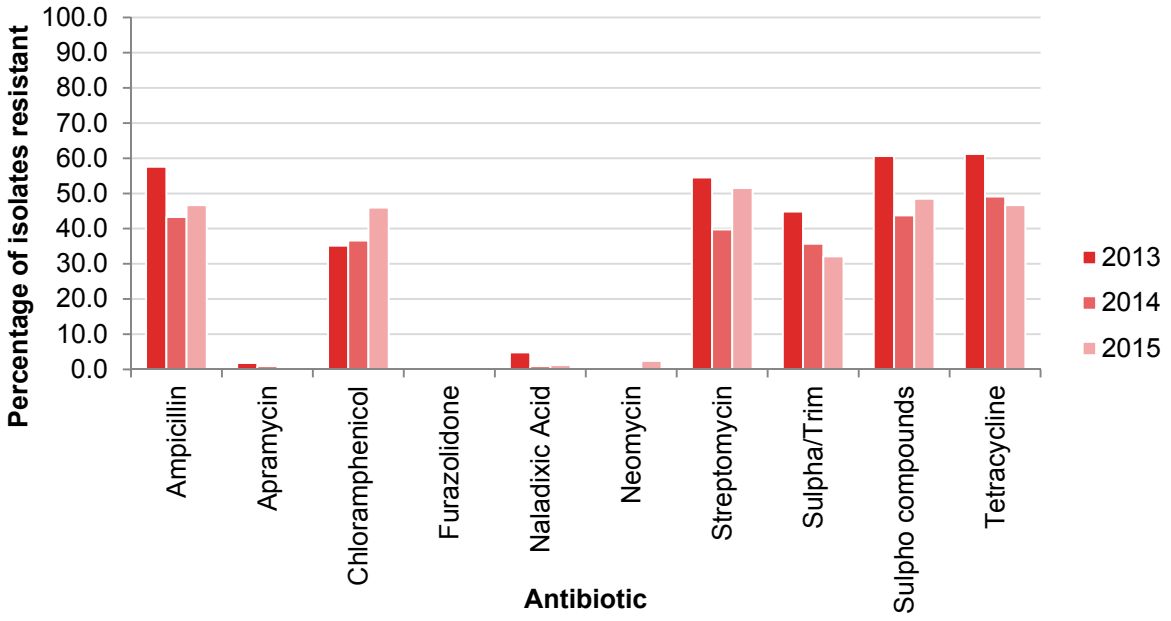
Forty-one percent of 165 isolates of *S.* Typhimurium examined in 2015 were sensitive to all of the antibiotics tested (Figure 4.18), which is a slight decrease compared to 44.2% in 2014, but an increase from 30.5% in 2013.

Between 2008 and 2014 the prevalence of resistance to sulphamethoxazole/trimethoprim has fluctuated between 26.4%-44.9%, and a level of 32.1% was seen in 2015. Isolates from pigs have predominantly accounted for these fluctuations as a high proportion of many definitive types of *S.* Typhimurium isolated from pigs are resistant to sulphamethoxazole/ trimethoprim.

No resistance to apramycin was detected in 2015. Apramycin resistance had increased for *S.* Typhimurium in 2011 and 2012 to 20.4%, a notable change when compared with preceding years, where apramycin resistance had been consistently less than 5%. More recently, apramycin resistance dropped to the low levels observed prior to 2011 (1.8% in 2013, 0.9% in 2014). Isolates resistant to apramycin were also resistant to gentamicin.

There were no isolates of *S.* Typhimurium resistant to ceftazidime, cefotaxime, ciprofloxacin, amoxicillin/clavulanate, furazolidone or amikacin recovered in 2015, The third generation cephalosporins and fluoroquinolones are often considered the first-line treatments for gram-negative invasive infections in man and might therefore be indicated for treatment of people with invasive or severe cases of Salmonellosis.

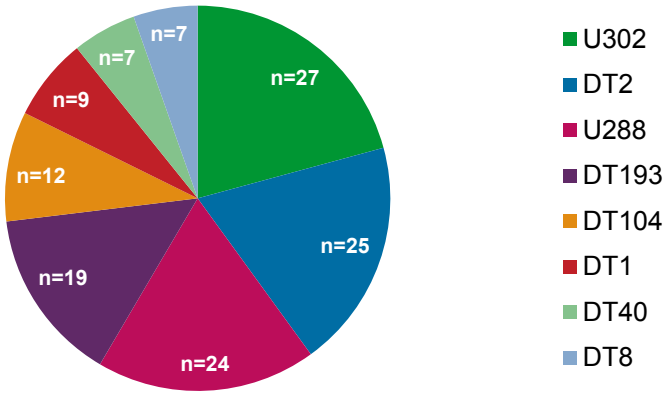
Figure 4.18: *Salmonella* Typhimurium: percentage of resistant isolates in 2013 (n=165), 2014 (n=224) and 2015 (n=165)



The eight most frequent definitive or undefined types subjected to susceptibility testing at APHA are given in Figure 4.19.

The generally high level of resistance of *Salmonella* Typhimurium isolates observed in recent years has partly been a reflection of the contribution of DT104 and its variants DT104B and U302, which have comprised more than a quarter of isolates in some years over the previous decade. Only 2.6% (1/39) of DT104 and U302 isolates were sensitive to all the antibiotics tested in 2015. No DT104B were isolated in 2015. The proportion of *Salmonella* Typhimurium isolates comprising DT104 and its variants has however declined significantly when a longer time period is considered. For further information on the phage types prior to 2015 please refer to the *Salmonella* in Livestock Production.

Figure 4.19: Number of isolates of *Salmonella* Typhimurium of the eight most frequent definitive or undefined types subject to susceptibility testing in 2015



Monophasic *Salmonella* Serotypes

Eighty-three isolates of the monophasic *Salmonella* 4,12:i:- were examined, belonging to phage types 120 (n=2), 193 (n=69), U302 (n=1) and U311 (n=2). Nine isolates were not typeable or reacted with phages but did not conform to a recognised phage type. Most isolates were from pigs (63.8%) with feed the next most common source of origin (9.6%). The most common pattern of resistance observed was to ampicillin, streptomycin, sulphonamide compounds and tetracycline (AmSSuT), occurring in 27/69 DT 193 isolates, 2/2 U311 isolates and 8/8 of the isolates which were not typeable with phages. 60/69 DT 193 isolates (86.9%) had the basic AmSSuT resistance pattern alone or with one or more additional resistances.

A total of 68 isolates of the monophasic *Salmonella* 4,5,12:i:- were examined, including phage types 191a (n=1), 193 (n=62), 29 (n=1), 8 (n=1), and U323 (n=1). One isolate was un-typeable and one isolate had no phage type information. The most common resistance pattern in DT 193 isolates was AmSSuT, occurring in 59.6% of isolates (37/62). Most isolates of DT 193 were from pigs (66.1%).

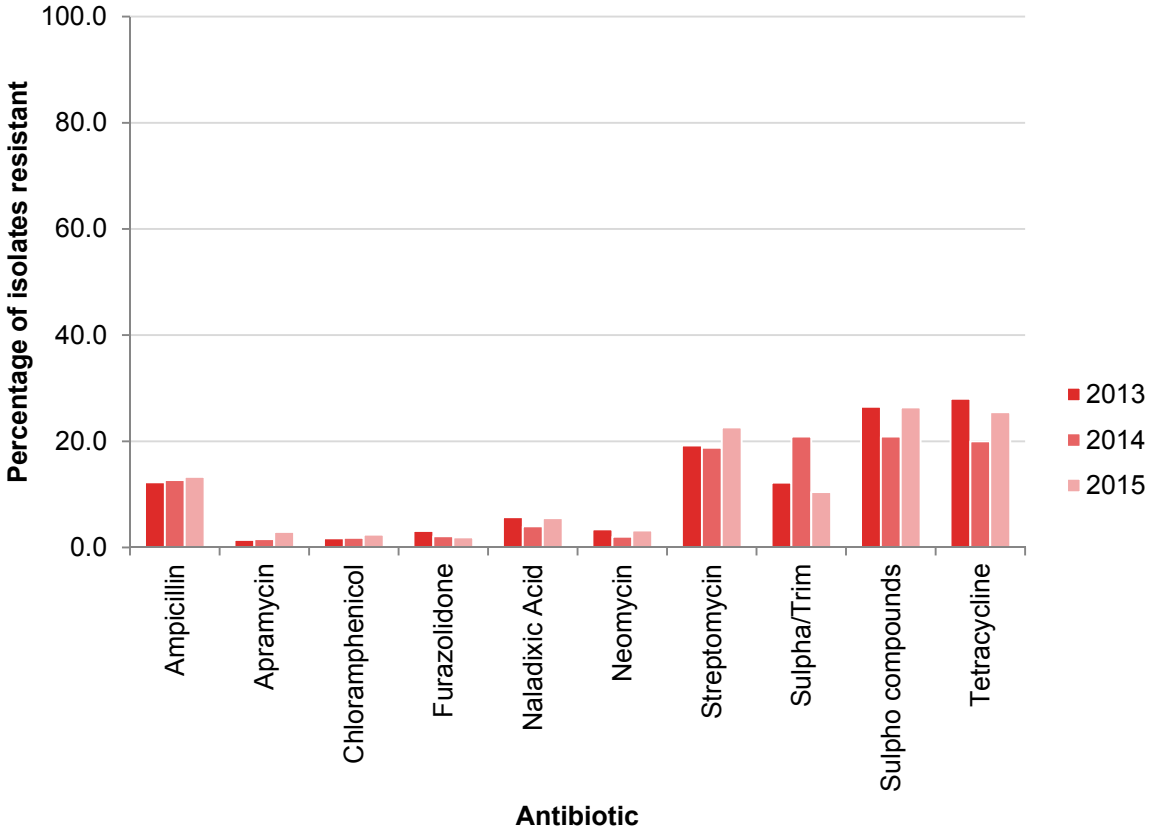
Salmonella other than Dublin or Typhimurium

Of the 2,198 isolates of serotypes other than *S*. Dublin and *S*. Typhimurium tested in 2015, 60.2% were sensitive to all the antibiotics in the panel, a decrease on the figure for 2014, when 68.2% were fully sensitive. One hundred and thirty-three (6.0%) of these isolates were *S.* Enteritidis of which 97/133 (72.9%) were fully susceptible. Resistance to one or more antibiotics was detected in *S*. Enteritidis isolates belonging to phage types 21, 35, 4, 4b, 8, 9b. No resistance was detected in isolates belonging to phage type 1, 11, 14b, 21b, 3, 33, 6a or 9a.

Neomycin resistant isolates originated mainly from chickens (761 isolates; 3.7% resistant), ducks (191 isolates; 7.8% resistant) and pigs (120 isolates; 8.3% resistant). The majority of the neomycin-resistant isolates from chickens were *Salmonella* Ohio (the same situation prevailed in 2011 - 2014). In ducks, *S*. Indiana was the main serotype showing resistance to neomycin (11/68 isolates resistant). The *S*. Indiana isolates from ducks were also frequently resistant to furazolidone (18/68 isolates).

The apparent increase in the prevalence of resistance to streptomycin, sulphonamides and tetracyclines which was observed following 2009 reflected in part the increased monitoring of turkeys that has occurred in between 2010 and 2013 under the Control of *Salmonella* in Turkeys Order. When looking at *Salmonella* isolates other than Typhimurium and Dublin from turkeys in 2015 (n=250), 71.2% were resistant to streptomycin, 75.6% to sulphonamides and 73.6% to tetracyclines. This is lower than the equivalent figures for pigs in 2014 (78-89%), but higher than those for chickens (15-20%) and cattle (7-9%).

Figure 4.20: Salmonella other than Dublin and Typhimurium, percentage of isolates resistant to antibiotics tested in 2013 (n=2328), 2014 (n=1837) and 2015 (n=2198)



References

Animal and Plant Health Agency (APHA), (2014). *Salmonella* in livestock production in Great Britain, 2015. [Accessed online 15/11/2016: https://www.gov.uk/government/publications/salmonella-in-livestock-production-in-great-britain-2015]

Anjum, M.F., Duggett, N.A., AbuOun, M., *et al.* (2016). Colistin resistance in *Salmonella* and *Escherichia coli* isolates from a pig farm in Great Britain. *Journal of Antimicrobial Chemotherapy.* 71: 2306-2313.

Duggett N.A., Anjum, M.F., Teale, C., *et al*. Occurrence and characterisation of *mcr-1* harbouring *Escherichia coli* isolated from pigs in Great Britain from 2013-2015. *Journal of Antimicrobial Chemotherapy* (in press).

Duinhof, T. F., Dierikx, C.M., Koene, M.G.J., *et al.* (2008). Multiresistentie bij *Brachyspira hyodysenteriae*-isolaten op een varkensvermeerderingsbedrijf in Nederland. *Tijdschrift voor Diergeneeskunde.* 133:604-608.

European Commission. (2013). Implementing Decision 2013/652/EU 'on the monitoring and reporting of antimicrobial resistance in zoonotic and commensal bacteria'. *Official Journal of the European Union.* 303/26. [Accessed online 15/11/2016: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0653&from=EN]

European Commission. (2007). Decision 'concerning a financial contribution from the Community towards a survey on the prevalence and antimicrobial resistance of *Campylobacter* spp. In broiler flocks and on the prevalence of *Campylobacter* spp. and *Salmonella* spp. in broiler carcasses to be carried out in the Member States. *Official Journal of the European Union*. 190/25. [Accessed online 15/11/2016: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007D0516&from=EN]

European Commission. (2005). Regulation (EC) No 2073/2005 'on microbiological criteria for foodstuffs'. *Official Journal of the European Union.* 338/1. [Accessed online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:338:0001:0026:EN:PDF]

European Commission. (2016). Commission's Communication on a One-Health Action Plan to support Member States in the fight against Antimicrobial Resistance (AMR). [Accessed online 03/11/2016: http://ec.europa.eu/smart-regulation/roadmaps/docs/2016_sante_176_action_plan_against_amr_en.pdf].

EFSA (European Food Safety Authority). (2007). Report including a proposal for a harmonized monitoring scheme of antimicrobial resistance in *Salmonella* in fowl (*Gallus gallus*), turkeys, and pigs and *Campylobacter jejuni* and *C. coli* in broilers. *EFSA Journal*. 96:1-46.

EFSA (European Food Safety Authority), (2008). Report from the Task Force on Zoonoses Data Collection including guidance for harmonized monitoring and reporting of antimicrobial resistance in commensal *Escherichia coli* and *Enterococcus* spp. from food animals. *EFSA Journal*. 141:1-44.

EFSA (European Food Safety Authority), (2010). The Community Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from animals and food in the European Union in 2008. *EFSA Journal*. 8:1658, 261 pp.

EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), (2011). The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in the European Union in 2009. *EFSA Journal*.9:2154, 321 pp.

EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), (2012). The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2010. *EFSA Journal*. 10:2598, 233 pp.

EFSA (European Food Safety Authority), (2012). Technical specifications for the analysis and reporting of data on antimicrobial resistance in the European Union Summary Report. *EFSA Journal*. 10:2587, 53 pp.

EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), 2013. The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2011. 2013. *EFSA Journal*. 11:3196, 359 pp. doi:10.2903/j.efsa.2013.3196.

ESVAC. (European Surveillance of Veterinary Antimicrobial Consumption), (2016). Sales of veterinary antimicrobial agents in 29 European countries in 2014. Trends from 2011 to 2014. (EMA/61769/2016). [Accessed online 03/11/2016: http://www.ema.europa.eu/docs/en_GB/document_library/Report/2016/10/WC500214217.pdf]

ESVAC. (European Surveillance of Veterinary Antimicrobial Consumption). (2011). Trends in the sales of veterinary antimicrobial agents in nine European countries (2005-2009). (EMA/238630/2011) [accessed online 15/11/2016: http://www.ema.europa.eu/ema/pages/includes/document/open_document.jsp?webContentId=WC500112309]

FAO (Food and Agriculture Organisation of the United Nations), (2016). The FAO Action Plan on Antimicrobial Resistance, 2016-2020. [Accessed online 03/11/2016: http://www.fao.org/3/a-i5996e.pdf]

García-Álvarez, L., Holden, M.T., Lindsay, H., *et al*. (2011). Methicillin-resistant *Staphylococcus aureus* with a novel *mecA* homologue in human and bovine populations in the UK and Denmark: a descriptive study. *Lancet Infectious Diseases.* 11:595–603.

Hinton, M. (1986). The ecology of *Escherichia coli* in animals including man with particular reference to drug resistance. *Veterinary Record*. 119:420-426.

Liu, Y.Y., Wang, Y., Walsh, T.R. *et al*. (2015). Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study. *Lancet Infectious Disease*. 16:161-8.

OIE (World Organisation for Animal Health), (2016). Combating Antimicrobial Resistance through a One-Health Approach: Actions and OIE Strategy. [Accessed online: http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/A_RESO_AMR_2016.pdf]

Randall, L.P., Lemma, F., Rogers, J.P., Cheney, T.E., Powell, L.F., Teale, C.J. (2014). Prevalence of extended-spectrum-beta-lactamase-producing Escherichia coli from pigs at slaughter in the UK in 2013. *Journal of Antimicrobial Chemotherapy*. 69:2947-50.

Rønne, H., and Szancer, J. (1990). In vitro susceptibility of Danish field isolates of *Treponema hyodysenteriae* to chemotherapeutics in swine dysentery (SD) therapy. Interpretation of MIC results based on the pharmacokinetic properties of the antibacterial agents. *Proceedings of the 11th IPVS Congress.* Lausanne, Switzerland, July 1 to 5, p 126.

Schwarz, S., Johnson, A.P. (2016). Transferable resistance to colistin: a new but old threat. *Journal of Antimicrobial Chemotherapy*. 71:2066-2070

Schwarz, S., Woodford, N., van Duijkeren, E., Johnson, A.P., and Gaastra, W. (2010). Assessing the antimicrobial susceptibility of bacteria obtained from animals. *Veterinary Microbiology.* 141:1-4.

The Review on Antimicrobial Resistance. (2016). Tackling drug-resistant infections globally: Final report and recommendations. [Accessed online 03/11/2016: https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf]

Vanderhaeghen, W., Cerpentier, T., Adriaensen, C., Vicca, J., Hermans, K., and Butaye, P. (2010). Methicillin-resistant *Staphylococcus aureus* (MRSA) ST398 associated with clinical and subclinical mastitis in Belgian cows. *Veterinary Microbiology*. 144:166-171.

Veterinary Medicines Directorate. (2013). 'UK Veterinary Antibiotic Resistance and Sales Surveillance Report, 2012.' *VMD.* [Accessed online, 27/10/2016: http://webarchive.nationalarchives.gov.uk/20140909112428/http://www.vmd.defra.gov.uk/pdf/varss.pdf]

Vet Times. (2015). 'VMD releases more details of UK *mcr-1* gene tests'. *Vet Times.* [Accessed online, 27/10/2016: https://www.vettimes.co.uk/news/vmd-releases-more-details-of-uk-mcr-1-gene-tests/]

World Health Organisation (WHO). (2011). 'Critically important Antimicrobials for Human Medicine'. [Accessed online, 27/10/2016: http://apps.who.int/iris/bitstream/10665/77376/1/9789241504485_eng.pdf?ua=1&ua=1]

World Health Organisation. (2016). United Nations General Assembly (UNGA) meeting, 21 September 2016 [Accessed online, 27/10/2016: http://www.who.int/antimicrobial-resistance/events/UNGA-meeting-amr-sept2016/en/

Annexes

Annex 1: Changes in Methodology

The European Commission (EC) has requested the European Medicines Agency (EMA) to take the lead in collating data collected on the use of antibiotic agents in animals in the European Union. The EMA has therefore developed 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 antibiotics.

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 publications use a different method to calculate mg/PCU compared to the approach previously used in the UK. Table A1.1 summarises these differences, which are also highlighted in Figure A1.2 and Table A1.2.

Table A1.1: Differences between the ESVAC and VARSS methodology used in previous publications for the calculation of quantity of antibiotic sold

	UK-VARSS	ESVAC
Products included	↑ All authorised veterinary antibiotic products.	↓ Topical presentations are not included.
Calculation of active ingredient quantity	↓ Ingredients are converted to active moiety (the active molecule not including salts)	↑ Active ingredient weights relate directly to information held within the SPC
Calculation of PCU	↑ Horses not included as food producing animals	↓ Horses included as food producing animals
Calculation of mg/PCU	↓ Only takes into account products which are authorised for use in food producing animals *only*. **Horses are excluded**. Takes into account all administration routes.	↑ All formulations (*for all species*) other than tablets included; it is considered that tablets are primarily used in the treatment of non-food producing animals.
Conclusion	**Likely underestimates mg/PCU**	**Likely overestimates mg/PCU**

Key:

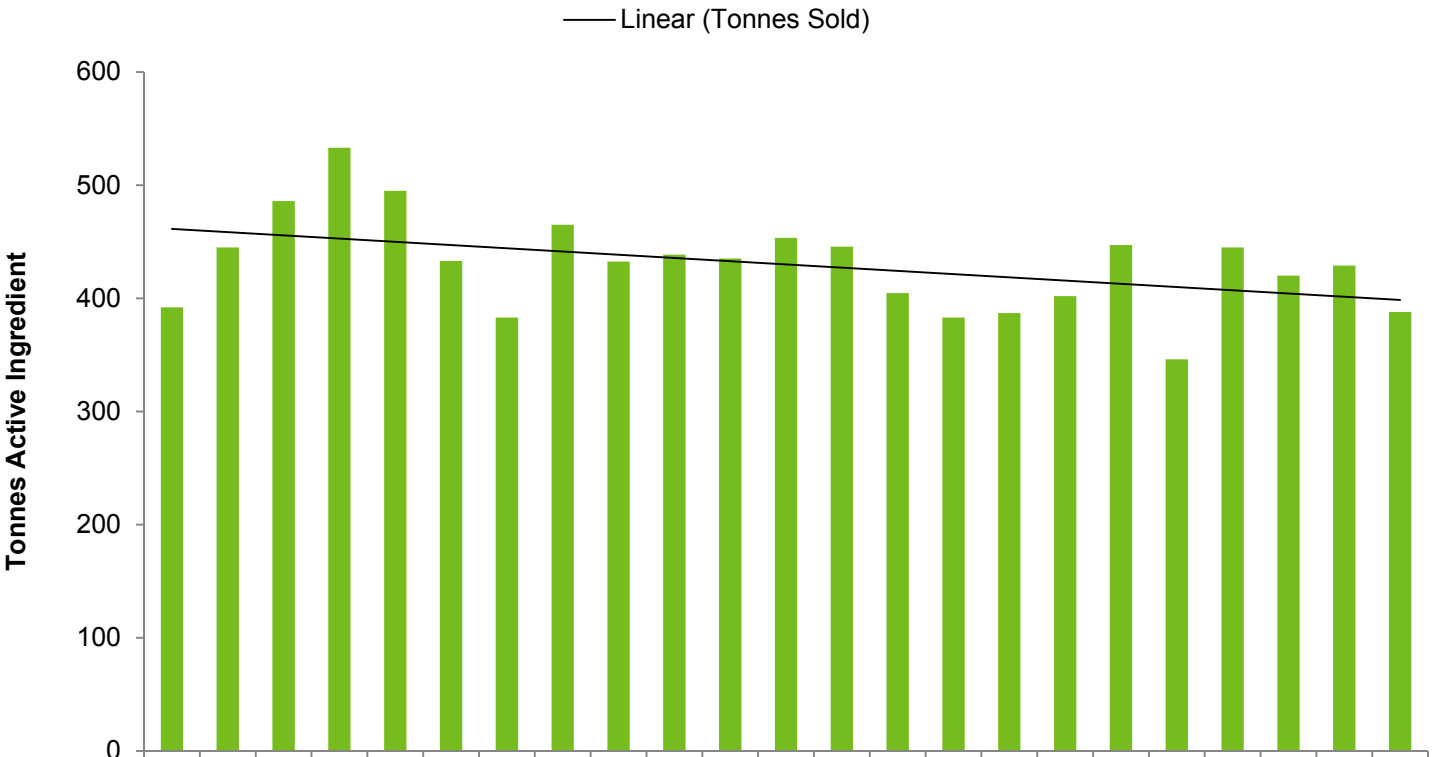
↑ = Increases overall mg/PCU

↓ = Decreases overall mg/PCU

In order to harmonise the national and European reporting, the ESVAC methodology has been adopted in the current UK- VARSS report for the first time. The historical data based on the traditional UK methodology, as well as 2015 data calculated in the same way, can be seen in Figure A1.1.

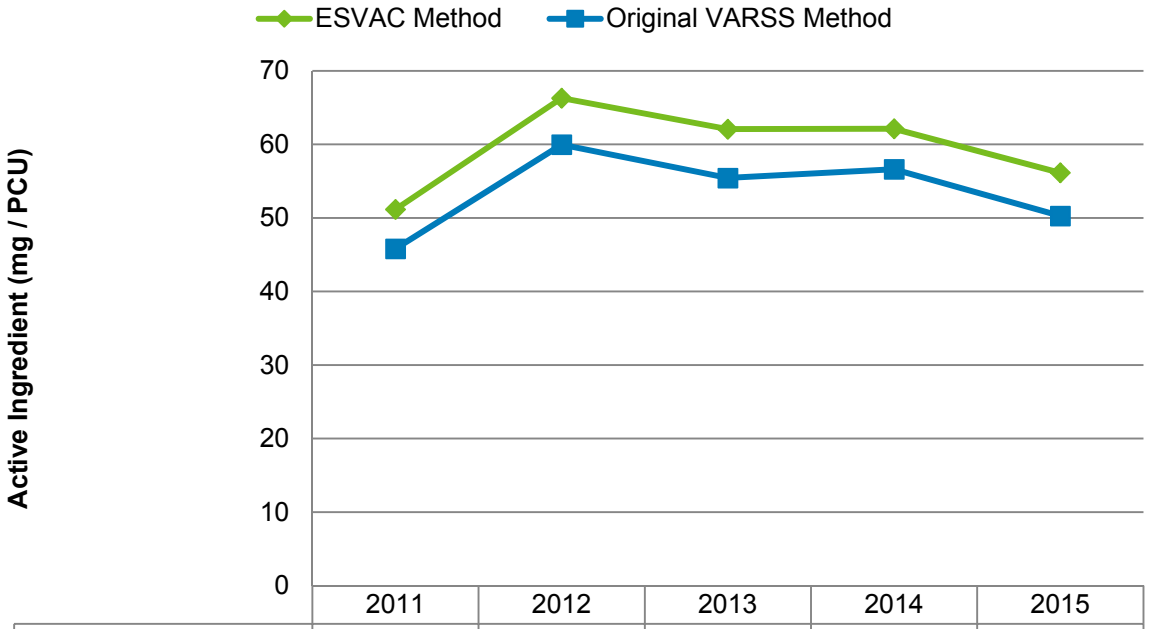
Data have been collected from Market Authorisation Holders since 1993, although this was only a statutory requirement from 2005. Data shown in Figure A1.1 represent sales of antibiotics for therapeutic use only, and do not contain sales of products marketed as growth promoters, which were banned in 2006.

Figure A1.1: Tonnes of active ingredient of antibiotic sold for all species 1993-2015 using the original UK-VARSS methodology



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Tonnes Sold	392	445	486	533	495	433	383	465	432	439	435	453	446	405	383	387	402	447	346	445	420	429	388

Figure A1.2: Milligrams (mg) of active ingredient of antibiotic sold for food producing species per Population Correction Unit (PCU) 2011-2015 calculated using the ESVAC and original UK-VARSS methodology



	2011	2012	2013	2014	2015
ESVAC Method	51	66	62	62	56
Original VARSS Method	46	60	55	57	50

Table A1.2: Comparison of UK-VARSS and ESVAC methodology for the calculation on tonnes of active ingredient sold, Population Correction Unit (PCU), and milligrams (mg) of active ingredient sold per PCU for food producing species, 2011-2015.

	2011		2012		2013		2014		2015	
	VARSS	ESVAC	VARSS	ESVAC	VARSS	ESVAC	VARSS	ESVAC	VARSS	ESVAC
Tonnes of active ingredient	290	344	381	447	355	422	369	430	330	392
PCU	6330	6724	6354	6749	6404	6799	6518	6915	6584	6961
mg/PCU	46	51	60	66	55	62	57	62	50	56

Figure A1.3 shows historical data for mg/PCU for 2005-2015, calculated using ESVAC methodology. The data represented accounts for sales of antibiotics for food producing animals only, inclusive of horses.

Figure A1.3: Milligrams (mg) of active ingredient of antibiotic sold for food producing species per Population Correction Unit (PCU) 2005-2015 using the ESVAC methodology

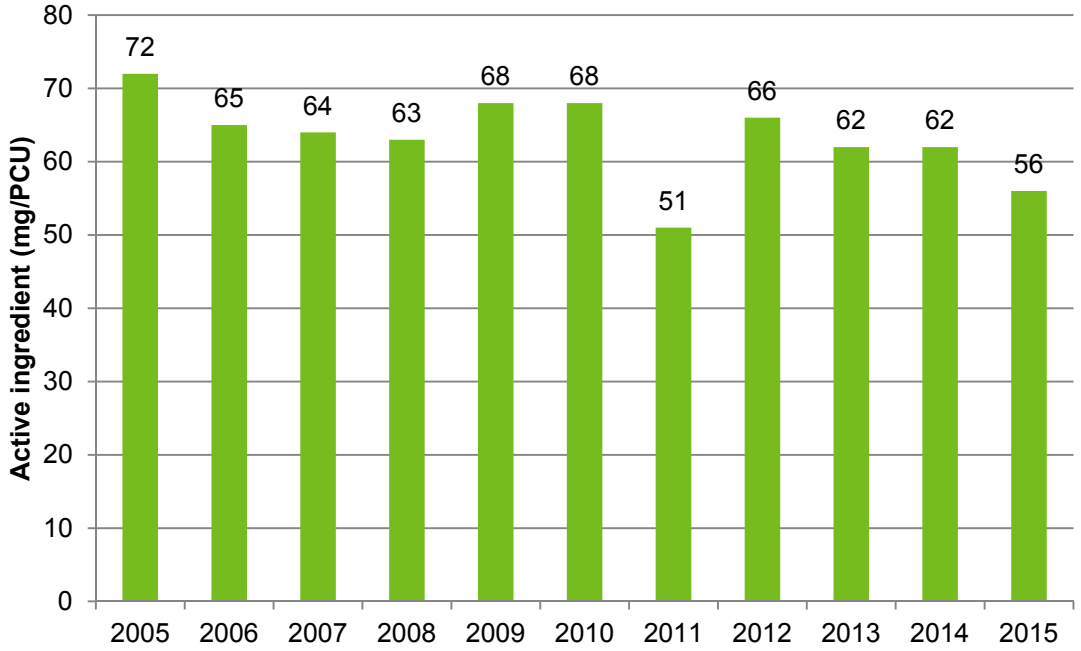


Table A1.3 shows the sales for other antibiotic products, which include topical preparations and those for sensory organs e.g. aerosols, creams, gels, shampoos and ear and eye medications (not included in ESVAC calculation).

Table A1.3: Tonnes of active ingredient of antibiotic sold for all species by "other" routes of administration 2011-2015

	2011	2012	2013	2014	2015
Others	2	2	2	3	2

Annex 2: European Population Correction Unit (PCU)

When assessing antibiotic sales it is important that the demographics of the animal population potentially exposed to treatment are also taken into account, (see Annex 19 - data limitations). Table A2.1 shows the living population of UK 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 to take into account seasonality or animals whose lives are shorter than a year.

Table A2.1: Number of livestock (in thousands) by food producing species 2011-2015

	2011	2012	2013	2014	2015*
Cattle	9933	9900	9844	9837	9919
Pigs	4441	4481	4885	4815	4739
Sheep	31634	32215	32856	32856	33337
Poultry**	162551	160061	162609	162609	167579

* 2015 Data are provisional as they have not been fully validated at the time of printing
**Census data are an underestimate of the poultry population

In addition, census data do not take into account the weight of each particular species at the time of treatment with antibiotics. This is achieved through use of the PCU, a technical unit of measurement (where 1 PCU = 1kg of animal treated), which is calculated by multiplying a standardised average weight at time of treatment (see Table A1.3) with the associated annual animal/ slaughter numbers. The calculation also 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.

Table A2.2 shows the calculated combined UK PCU value for food producing species and horses. The standard formula used for calculation of the PCU for poultry does not include population figures for egg producers (laying hens) so the poultry PCU is an underestimate (EMA, 2011).

Table A2.2: Population correction unit (PCU) (in thousand tonnes) by food producing species and total 2011-2015

	2011	2012	2013	2014	2015
Total food producing species + horses*	6724	6749	6799	6915	6961
Sheep and goat	2661	2697	2760	2809	2795
Cattle	1767	1708	1692	1731	1743
Poultry	1012	1040	1059	1042	1082
Pig	717	733	716	745	770
Horses**	395	395	395	395	378
Fish	172	176	177	193	***

* Total food producing species PCU includes cattle, pigs, sheep, goats, poultry (broilers), fish and horses.
** Horse population data are obtained from the British Equestrian Trade Association survey which is run every 5 years.
*** UK aquaculture population statistics for 2015 are not yet available as they are collated through 2016. Therefore, for fish PCU calculation purposes, 2014 data have been used.

Companion animals are not included in the PCU as reliable population data cannot be collected and no agreed weights at time of treatment have been allocated for these species.

Table A2.3: Average weights at time of treatment (kg) used to calculate the Population Correction Unit (PCU)

Animal Category	Average weight at treatment (kg)	Source
Cattle		
Slaughter cows	425	Montforts (1999)[1]
Slaughter heifers	200	EMA[2]
Slaughter bullocks and bulls	425	Montforts (1999)[1]
Slaughter calves and young cattle	140	Montforts (1999)1; EMA[2]
Imported/ exported cattle for slaughter	425	Montforts (1999)[1]
Imported/ exported cattle for fattening	140	Montforts (1999)[1]
Livestock dairy cows	425	Montforts (1999)1; EMA[2]
Pigs		
Slaughter pigs	65	Montforts (1999)[1]
Imported/ exported pigs for slaughter	65	Montforts (1999)[1]
Imported/ exported pigs for fattening	25	M. Goll (Eurostat, personal comm.)
Livestock sows	240	Montforts (1999)[1]
Poultry		
Slaughter broilers	1	Montforts (1999)1; EMA[2]
Slaughter turkeys	6.5	Montforts (1999)1; EMA[2]
Imported/ exported poultry for slaughter	1	Montforts (1999)1; EMA[2]
Sheep and goats		
Slaughter sheep and goats	20	Montforts (1999)[1]
Imported/ exported sheep and goats for slaughter	20	Montforts (1999)[1]
Livestock sheep	75	Montforts (1999)[1]
Horses		
Living horses	400	Montforts (1999)1; EMA[2]
Fish[5]		
Rabbits		
Slaughter rabbits	1.4	EMA[2]

1 M.H.M.M. Montforts 1999. Environmental risk assessment for veterinary medicinal products. Part 1. Other than GMO-containing and immunological products. First update.
2 European Medicines Agency (EMA). Revised guideline on environmental impact assessment for veterinary medicinal products in support of the
VICH guidelines GL6 and GL 38 (EMEA/CVMP/ERA/418282/2005-Rev.1).
3 Assume broilers.
4 Assume lambs.
5 Data form Eurostat is given as 1,000 tonnes slaughtered fish (as live weight).

Annex 3: Antibiotic Active Ingredients Authorised for Use in Animals

Class/Active Ingredient	Authorised Species
Tetracyclines	
Chlortetracycline	Cattle, Pigs, Sheep, Chickens, Turkey, Ducks
Doxycycline	Pigs, Chickens, Turkey, *Cats, Dogs, Pigeons*
Oxytetracycline	Cattle, Pigs, Sheep, Chickens, Salmon, Trout, *Dogs, Cats, Horses*
Tetracycline	Cattle, Pigs, Chickens
Potentiated Sulphonamides	
Sulfadiazine	Cattle, Pigs, Chickens, Turkey, *Cats, Dogs, Horses*
Sulfadimethoxine	*Pigeons*
Sulfadimidine	Cattle, Pigs, Sheep
Sulfadoxine	Cattle, *Horses*
Sulfamethoxazole	Pigs, Chickens
Trimethoprim	Cattle, Pigs, Chickens, Turkey, *Cats, Dogs, Horses*
Beta-lactams	
1st Generation Cephalosporins	
Cefalexin	Cattle, *Cats, Dogs*
Cefalonium	Cattle
Cefapirin	Cattle
*3rd Generation Cephalosporins**	
Cefoperazone	Cattle
Cefovecin	*Cats, Dogs*
Ceftiofur	Cattle, Pigs, *Horses*
*4th Generation Cephalosporins**	
Cefquinome	Cattle, Pigs, *Horses*
Penicillins	
Amoxicillin	Cattle, Pigs, Sheep, Chickens, Turkey, Ducks, Salmon, *Cats, Dogs, Pigeons*
Ampicillin	Cattle, Pigs, Sheep, *Cats, Dogs*
Benzylpenicillin	Cattle, Pigs, Sheep, Chickens, *Cats, Dogs, Horses*
Cloxacillin	Cattle, Sheep, *Cats, Dogs, Horses*
Nafcillin	Cattle
Phenoxymethylpenicillin	Pigs
Aminoglycosides	
Apramycin	Cattle, Pigs, Chickens
Dihydrostreptomycin	Cattle, Pigs, Sheep, *Cats, Dogs, Horses*
Framycetin	Cattle, *Cats, Dogs*
Gentamicin	*Cats, Dogs, Horses, Rabbits*
Kanamycin	Cattle

Neomycin	Cattle, Sheep, *Cats, Dogs, Horses*
Spectinomycin	Cattle, Pigs, Sheep, Chickens
Streptomycin	Cattle, Sheep, *Cats, Dogs, Horses*
Fluoroquinolones*	
Danofloxacin	Cattle, Pigs
Difloxacin	Cattle, Chickens, Turkeys, *Dogs*
Enrofloxacin	Cattle, Pigs, Sheep, Chickens, Turkeys, Goats, *Cats, Dogs, Rabbits, Reptiles, Ornamental Birds, Rodents*
Marbofloxacin	Cattle, Pigs, *Cats, Dogs*
Orbifloxacin	*Dogs*
Pradofloxacin	*Cats, Dogs*
Macrolides	
Erythromycin	Chickens
Gamithromycin	Cattle
Spiramycin	Cattle, *Dogs, Cats*
Tildipirosin	Cattle, Pigs
Tilmicosin	Cattle, Pigs, Sheep, Chickens, Turkey, *Rabbits*
Tulathromycin	Cattle, Pigs
Tylosin	Cattle, Pigs, Chickens, Turkey
Tylvalosin	Pigs, Chickens, Turkey, Game Birds
Other	
Amphenicols	
Florfenicol	Cattle, Pigs, Sheep, Salmon
Lincomycins	
Lincomycin	Cattle, Pigs, Chicken, *Cats, Dogs*
Clindamycin	*Cats, Dogs*
Pirlimycin	Cattle
Pleuromutilins	
Tiamulin	Pigs, Chickens, Turkey, *Rabbits*
Valnemulin	Pigs, *Rabbits*
Polymixins	
Colistin	Cattle, Pigs, Sheep, Chickens
Polymixin B	*Cats, Dogs*
Steroidal antibiotics	
Fusidic acid	*Cats, Dogs, Rabbits*

*denotes the classes of antibiotics which are considered 'highest priority critically important antibiotics for people' (HP-CIAs) based on classification by European Medicines ad hoc expert group on AMR.

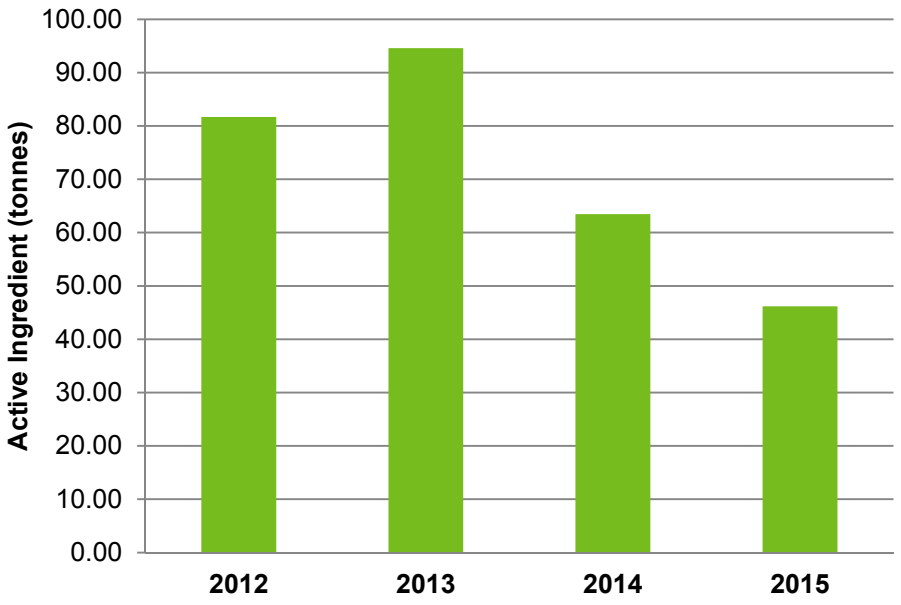
Non- food producing species are indicated in italics

Annex 4: Antibiotic Usage Data from British Poultry Council

In 2015, the British Poultry Council (BPC) reported the use of 46.18 tonnes of antibiotic active ingredient. This represents a reduction of 27% (17.28 tonnes) between 2014 and 2015, whereas the poultry population has remained steady (see Annex 2). This is the lowest reported value over the four years that BPC have been collecting these data, as demonstrated in Figure A4.1. Peak use was recorded in 2013, and BPC have indicated that this may have been associated with poor feed quality that year. Feed quality can significantly impact the intestinal health of the birds and is dependent on weather conditions during the growing and harvest period.

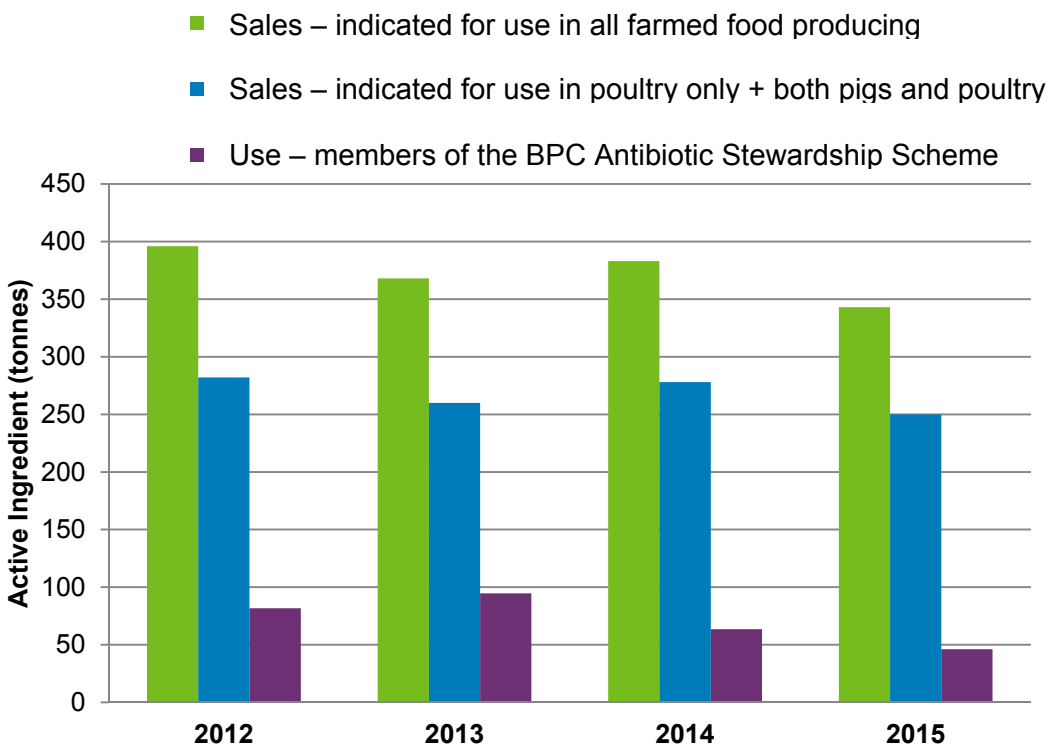
When looking specifically at chickens and turkeys reared for meat production, 43.18 tonnes of antibiotics were administered, which represents 44 mg/PCU. The PCU was calculated by using 90% of the national statistics (given that members of the BPC Antibiotic Stewardship Scheme represent approximately 90% of the UK poultry meat production).

Figure A4.1: Tonnes of active ingredient of antibiotic used by all members of the BPC Antibiotic Stewardship Scheme 2012-2015



As highlighted in Figure A4.2 and Table A4.1, the decline in use in meat poultry species will have contributed to the 10% decline (40 tonnes) in the sales of antibiotic products authorised for farmed food producing species only and the 10% decline (28 tonnes) in the sales of antibiotic products authorised for use in poultry only + both pigs and poultry only between 2014 and 2015.

Figure A4.2: Tonnes of active ingredient of antibiotic sold indicated for use in all farmed food producing species only, indicated for use in poultry only + both pigs and poultry only* and used by members of the BPC Antibiotic Stewardship Scheme 2012-2015



* Does not include products indicated for use only in pigs

It is important to note the limitations when comparing this sales and use data. For example, some products licensed for poultry and both pigs and poultry may be used off license via the cascade in other species, and (unlike the BPC data) the poultry only + both pigs and poultry only sales data excludes products licensed for poultry +/- pigs alongside other species. Similarly, the BPC data also include products which are used off-label via the cascade within scope. These data are presented together to demonstrate the overall trend.

Table A4.1: Tonnes of active ingredient of antibiotic sold indicated for use in all farmed food producing species only, indicated for use in poultry only + both pigs and poultry only* and used by members of the BPC Antibiotic Stewardship Scheme 2012-2015*

	2012	2013	2014	2015
Sales – indicated for all farmed food producing species only	396	368	383	343
Sales – indicated for poultry only + both pigs and poultry only*	282	260	278	250
Use – members of the BPC Antibiotic Stewardship Scheme**	81.67	94.58	63.46	46.18

* Does not include products indicated for use only in pigs
**The figures are slightly adjusted from last year due to additional data being provided

Figure A4.3 shows that, when looking at antibiotic class, 93% were in the form of tetracyclines, amoxicillin and lincomycins.

Figure A4.3: Percentage of active ingredient of antibiotic used by members of the BPC Antibiotic Stewardship Scheme by class 2015

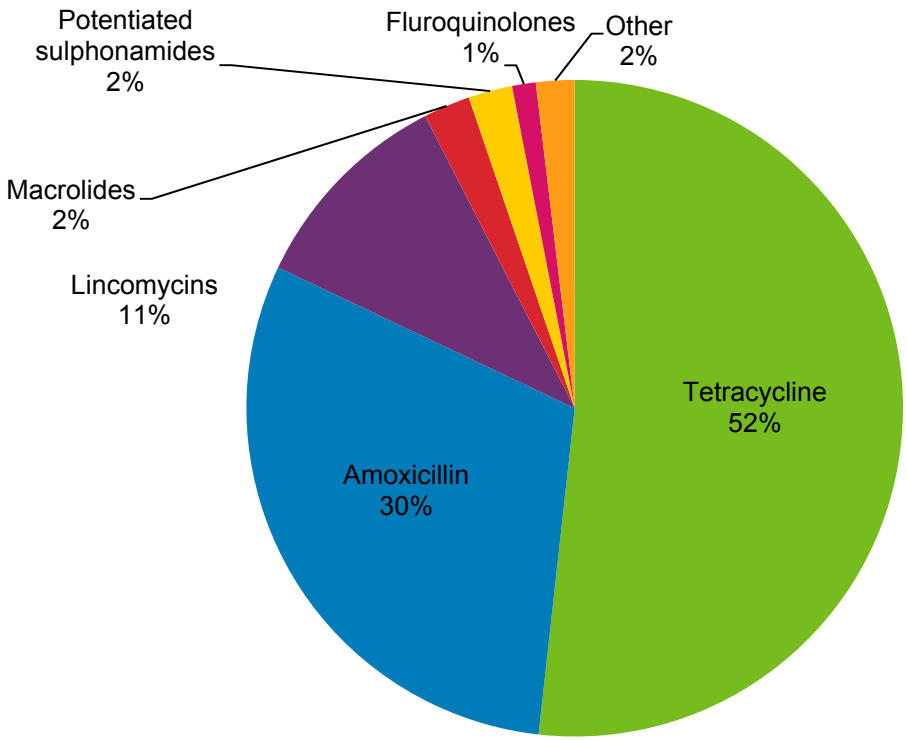


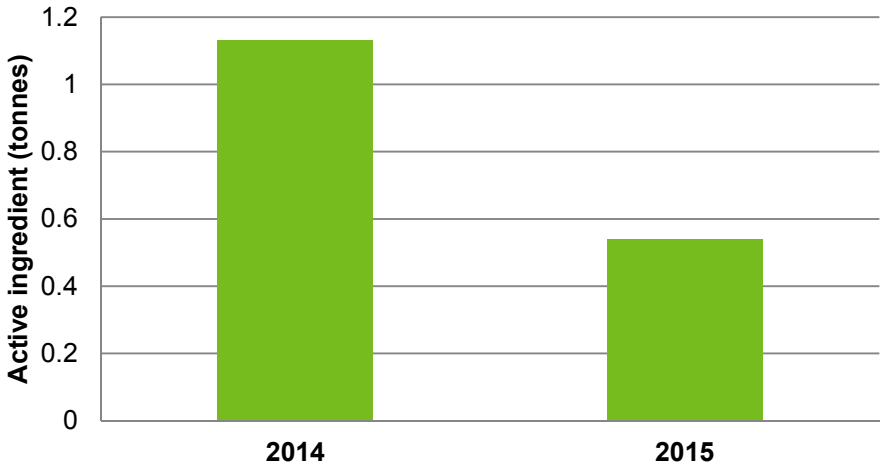
Table A4.2: Tonnes of active ingredient of antibiotic used by members of the BPC Antibiotic Stewardship Scheme by class 2015

	Tonnes	Percentage
Tetracycline	23.90	52
Amoxicillin	13.99	30
Lincomycins	4.81	11
Macrolides	1.06	2
Potentiated sulphonamides	1.00	2
Fluoroquinolones**	0.54	1
Other* Colistin**	0.88 0.04	2

* includes aminoglycosides, penicillin, pleuromutalin, colistin and products under the cascade
** highest priority critically important antibiotics

When looking at the highest priority critically important antibiotics, fluoroquinolones account for 1% of the volume of antibiotics used and Figure A4.4 shows that this dropped by over 50% between 2014 and 2015. In addition, 3rd and 4th generation cephalosporins are not used by the industry and the use of colistin (which was very low) has now been stopped by the BPC in its flocks.

Figure A4.4: Tonnes of active ingredient of fluoroquinolones used by members of the BPC Antibiotic Stewardship Scheme 2014-2015



In conclusion, the reductions in overall antibiotic use over the last 2 years and the reductions in fluoroquinolone use between 2014 and 2015 are highly commendable. This is likely to have been driven by the BPC's Antibiotic Stewardship Scheme (as highlighted in chapter 2), a programme of work designed to promote the responsible use of antibiotics and reduce the use of antibiotics classed as the most highly critical for human health.

Annex 5: 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 another species or 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 circumstances (for example 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 imported or human antibiotics used in animals in accordance with the prescribing cascade, as currently there is no mechanism by which such information can be obtained. The understanding is that use of human products in food producing species is not extensive, due to issues with longer withdrawal periods when using such products.

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

Annex 6: Summary of the EU Harmonised Monitoring Requirements of 2013/652/EU

	Sampling Year						
	2014	2015	2016	2017	2018	2019	2020
Salmonella spp. - broilers	x		x		x		x
Salmonella spp. - layers	x		x		x		x
Salmonella spp. - fattening turkeys	x		x		x		x
Salmonella spp. - broiler carcases	x		x		x		x
Salmonella spp. - fattening turkey carcases	x		x		x		x
Salmonella spp. - pig carcases		x		x		x	
Campylobacter jejuni - broilers	x		x		x		x
Campylobacter jejuni - fattening turkeys	x		x		x		x
E. coli - broiler caeca	x		x		x		x
E. coli - turkey caeca	x		x		x		x
E. coli - pig caeca		x		x		x	
ESBL, AmpC or carbapenemase producing *E. coli* - broiler caeca	x		x		x		x
ESBL, AmpC or carbapenemase producing *E. coli* - turkey caeca	x		x		x		x
ESBL, AmpC or carbapenemase producing *E. coli* - pig caeca		x		x		x	
ESBL, AmpC or carbapenemase producing *E. coli* - fresh broiler meat, pig meat and bovine meat gathered at retail	x	x	x	x	x	x	x
Campylobacter coli - broilers	x		x		x		x
Campylobacter coli - pigs		x		x		x	
E. faecium and *E. faecalis* - broilers, fattening turkeys, fattening pigs, bovines <1yr age	x	x	x	x	x	x	x

Key:
x = Mandatory
x = Voluntary
Pig and Bovine
Poultry

Note: The UK is exempt from the monitoring of resistance in isolates of bovine origin as we do not meet the cattle (<1 year of age) slaughter throughput as specified in the legislation.

Annex 7: Sources of the bacteria to meet the EU Harmonised Monitoring Requirements of 2013/652/EU

Escherichia coli

Monitoring of antibiotic resistance in indicator *E. coli* recovered from healthy pigs in 2015 was based on the EU technical specifications in Commission Decision 2013/652/EU.

These *E. coli* were isolated from caecal samples collected at slaughter from UK pigs (January 2015 – December 2015). In accordance with the sampling framework as specified in the legislation, each isolate taken forward for resistance testing originated from a different herd of pigs.

These results were submitted to EFSA and are expected to be published in the EU Summary Report on Antimicrobial Resistance for 2015 (EFSA and ECDC, in preparation).

***Salmonella* spp.**

Salmonella spp. isolates were recovered by Food Business Operators from pig carcase swab samples collected under Regulation 2073/2005, the microbiological criteria for foodstuffs. These samples were submitted by private laboratories to APHA, and one isolate per farm was taken forward for susceptibility testing.

The Food Standards Agency is the Competent Authority responsible for collating results on the number of samples collected under the Regulation 2073/2005 which are positive for *Salmonella*.

The low number of *Salmonella* received through this scheme is partly a reflection on the presence of *Salmonella* on pig carcases at slaughter, but it is also a reflection on the methodology used for sample collection and processing. In future years we will be working with colleagues in APHA and FSA to strengthen the robustness of this form of surveillance.

Annex 8: Disc diffusion breakpoints, corresponding MIC breakpoints and breakpoints under review for the clinical surveillance isolates included 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 R > 1mg/l	NA	NA	NA	R ≤ 13mm
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 R > 32mg/l	NA	NA	R ≤ 13mm	R ≤ 13mm
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 compounds (SU)	300	NA	≤ 13mm	NA	NA	NA

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 human clinical breakpoint

Animal and Plant Health Agency (APHA) historical veterinary disc diffusion zone size breakpoint and MIC corresponding to that zone size breakpoint

Animal Health and Veterinary Laboratories Agency (AHVLA) 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.
- The 16 antibiotics with antibiotic code e.g. amikacin (AK) are the set used for *Salmonella* susceptibility testing.
- Some *Haemophilus-Pasteurella-Actinobacillus* i.e. “HPA” organisms, for example *Actinobacillus pleuropneumoniae*, show a degree of intrinsic resistance to aminoglycosides.

* Erythromycin R ≤ 21mm for beta-haemolytic streptococci; R ≤ 19mm for other streptococci.
** Penicillin R ≤ 19mm for beta-haemolytic streptococci; R ≤ 16mm for other streptococci.
*** Tetracycline R ≤ 19mm for beta-haemolytic streptococci; R ≤ 23mm for other streptococci.

In Northern Ireland, an accredited CLSI method is used for testing and interpreting zones of inhibition (see table below). However, in Northern Ireland, *Salmonella spp.* isolates are also tested for Furazolidone, Framycetin, Apramycin and Spectinomycin using in-house break points.

Table A8.1: Antibiotic disc concentrations used in Northern Ireland

		Expected Zone diameter (mm)		
Antibiotic	**Disc**	**Resistant**	**Intermediate**	**Susceptible**
Ampicillin	AMP10	<=13	14-16	>=17
Chloramphenicol	C30	<=12	13-17	>=18
Gentamicin	CN10	<=12	13-14	>=15
Kanamycin	K30	<=13	14-17	>=18
Streptomycin	S10	<=11	12-14	>=15
Sulphonamides	S3.300	<=12	13-16	>=17
Tetracycline	TE30	<=11	12-14	>=15
Trimethoprim	W5	<=10	11-15	>=16
Furazolidone*	FR100		Not available	>=17
Nalidixic acid	NA30	<=13	14-18	>=19
Ciprofloxacin	CIP5	<=15	16-20	>=21
Cefotaxime	CTX30	<=22	23-25	>=26
Ceftazidime	CAZ30	<=17	18-20	>=21
Amoxicillin	AMC30	<=13	14-17	>=18
Framycetin*	FY100		Not available	
Apramycin*	APR15		Not available	
Spectinomycin*	SH100		Not available	

Annex 9: Comparison of 2015 ESBL results with those of previous UK surveys

A survey of multiple pathogens in pigs was performed by APHA in 2013. One component of the investigation examined ESBL producing *E. coli* in healthy UK pigs at slaughter. The method used in this survey differed to the method used in the 2015 EU monitoring. To enable comparison between this 2013 survey and the EU harmonised monitoring carried out in 2015, AHDB pork funded additional plating of pig caecal samples collected in 2015 on ESBL Brilliance agar (Oxoid, UK), as was done in the 2013 survey. The results of this survey have previously been published in the Journal of Antimicrobial Chemotherapy (Randall *et al,* 2014).

For the 2013 survey, samples from 637 pigs originating from 444 different farms, collected at 14 high-throughput abattoirs (which together process ~80% of slaughtered pigs in the UK) were collected between January and May and analysed.

For the 2015 survey, samples from 300 pigs from 300 different farms collected at six high throughput abattoirs (which together process ~60% of slaughtered pigs in GB) were collected between January and December and analysed.

Whilst the sample size, time of year for sampling and location of pigs varied between the two studies, both studies randomly sampled a large number of pigs from populations representative of ~60% or more of pigs slaughtered in the UK (in 2013) or GB (in 2015).

Table A9.1: Recovery of ESBL producing *E. coli* from pig caeca in 2015, compared with results from a 2013 pig survey

Number (and %) of caecal samples yielding *E. coli* on ESBL Brilliance agar in 2013	Number (and %) of caecal samples yielding *E. coli* on ESBL Brilliance agar in 2015
(132/637) **20.7%**	(63/300) **21.0%**

Annex 10: EU Harmonised Monitoring, results of Susceptibility testing in *Salmonella*

Table A10.1: Resistance in nine *Salmonella* spp. from pig caecal samples in 2015

	No. (%) of isolates resistant based on	
Antibiotic	**CBPs**	**ECVs**
Ampicillin	3 (33.3)	3 (33.3)
Azithromycin	*	*
Cefotaxime	0	0
Ceftazidime	0	0
Chloramphenicol	1 (11.1)	1 (11.1)
Ciprofloxacin	0	1 (11.1)
Colistin	0	0
Gentamicin	1 (11.1)	1 (11.1)
Meropenem	0	0
Nalidixic acid	1 (11.1)	1 (11.1)
Sulphonamide	*	4 (44.4)
Tetracyclines	3 (33.3)	3 (33.3)
Tigecycline	0	0
Trimethoprim	1 (11.1)	1 (11.1)

***Salmonella* spp. from pigs (n=9)**

* = No EUCAST breakpoint available

Annex 11: Clinical surveillance data for isolates from bovine mastitis cases

Table A11.1: Resistance (interpreted using BSAC CBPs) in *Escherichia coli* mastitis isolates, 2013-2015

	No. (%) of isolates resistant		
Antibiotic	**2013** (n=159)	**2014** (n=149)	**2015** (n=88)
Amoxi/Clav	13 (8.2)	11 (7.4)	13 (14.8)
Ampicillin	43 (27)	36 (24.2)	23 (26.1)
Cefotaxime	-	-	-
Cefpodoxime	1 (0.6)	3 (2)	2 (2.3)
Ceftazidime	-	-	-
Cefalexin	-	-	-
Enrofloxacin	0	4 (2.7)	0
Neomycin	11 (6.9)	6 (4)	4 (4.5)
Streptomycin	10 (6.3)	14 (9.4)	11 (12.5)
Tetracycline	13 (8.2)	17 (11.4)	16 (18.2)
Trimetho/Sulpho	13 (8.2)	13 (8.7)	9 (10.2)

Table A11.2: Resistance (interpreted using BSAC CBPs) of staphylococci and streptococci from mastitis cases, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	S. aureus			*S. uberis*			*S. dysgalactiae*		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amoxi/Clav	26/106 (24.5)	12/82 (14.6)	9/77 (11.7)	0	0	0	0	0	0
Ampicillin	31/106 (29.2)	29/82 (35.4)	25/77 (32.5)	1/120 (0.8)	0	0	0	0	0
Penicillin	23/89 (25.8)	29/82 (35.4)	25/77 (32.5)	1/119 (0.8)	0	0	0	0	0
Neomycin	0	0	2/77 (2.6)	83/119 (69.7)	72/121 (59.5)	79/119 (66.4)	4/47 (8.5)	10/41 (24.4)	3/36 (8.3)
Novobiocin	0	1/82 (1.2)	0	8/119 (6.7)	11/121 (9.1)	10/119 (8.4)	4/47 (8.5)	2/41 (4.9)	1/36 (2.8)
Tetracycline	13/106 (12.3)	3/82 (3.7)	4/77 (5.2)	70/120 (58.3)	66/122 (54.1)	62/123 (50.4)	43/47 (91.5)	35/41 (85.4)	34/36 (94.4)
Tylosin	1/106 (0.9)	1/82 (1.2)	2/77 (2.6)	24/120 (20)	20/122 (16.4)	14/123 (11.4)	4/47 (8.5)	4/41 (9.8)	2/36 (5.6)

Annex 12: Clinical surveillance data for isolates from respiratory infections of cattle, sheep, and pigs

Table A12.1: Resistance (interpreted using BSAC CBPs) of *Pasteurella multocida* and *Mannheimia haemolytica* from respiratory infections of cattle, 2013-2015

	No. (%) of isolates resistant					
	P. multocida			*M. haemolytica*		
Antibiotic	**2013** (n=39)	**2014** (n=29)	**2015** (n=42)	**2013** (n=17)	**2014** (n=12)	**2015** (n=28)
Amoxicillin/Clavulanic acid	0	0	0	0	0	0
Ampicillin	3 (7.7%)	1 (3.4%)	0	0	0	1 (3.6%)
Cefalexin	0	-	-	-	-	-
Cefpodoxime	1 (2.6%)	0	0	0	0	0
Enrofloxacin	0	0	0	0	0	0
Florfenicol	0	0	1 (2.5%)	0	2 (16.7%)	0
Tetracycline	19 (48.7%)	9 (31%)	16 (38.1%)	1 (5.9%)	3 (25%)	0
Trimethoprim/Sulphonamide	0	0	1 (2.4%)	0	0	0
Tylosin	-	-	-	-	-	-

Note: 33, 26 and 40 P. multocida isolates were tested for florfenicol susceptibility in 2013, 2014 and 2015, respectively. Only one P. multocida isolate was tested for cefalexin susceptibility in 2013.

Table A12.2: Resistance (interpreted using BSAC CBPs) of *Histophilus somni and Trueperella pyogenes* from respiratory infections of cattle, 2013-2015

	No. (%) of isolates resistant					
	H. somni			*T. pyogenes*		
Antibiotic	**2013** (n=14)	**2014** (n=10)	**2015** (n=7)	**2013** (n=12)	**2014** (n=13)	**2015** (n=8)
Amoxicillin/Clavulanic acid	0	0	0	0	0	0
Ampicillin	0	0	0	0	0	0
Cefalexin	-	-	-	0	0	0
Cefpodoxime	0	0	0	-	-	-
Enrofloxacin	0	0	0	-	-	-
Florfenicol	0	0	0	0	0	0
Tetracycline	0	0	0	7 (58.3%)	8 (61.5%)	5 (62.5%)
Trimethoprim/Sulphonamide	0	0	0	6 (50%)	3 (23.1%)	3 (37.5%)
Tylosin	-	-	-	0	0	1 (12.5%)

Annex 13: Clinical surveillance data for isolates from respiratory infections of pigs

Table A13.1: Resistance (interpreted using BSAC CBPs) of *Pasteurella multocida* and *Actinobacillus pleuropneumoniae* from respiratory infections of pigs, 2013-2015

	No. resistant / No. tested (Percentage resistant)					
	Pigs, P. multocida			*Pigs, A. pleuropneumoniae*		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amoxicillin/Clavulanic acid	0	0	0	0	0	0
Ampicillin	3/39 (7.7)	1/33 (3)	0	3/17 (17.6)	0	2/22 (9.1)
Apramycin	4/39 (10.3)	1/32 (3.1)	0	8/17 (47.1)	4/14 (28.6)	2/22 (9.1)
Cefpodoxime	0	0	0	0	0	0
Doxycycline	1/24 (4.2)	0	0	1/15 (6.7)	0	0
Enrofloxacin	0	0	0	0	0	0
Florfenicol	0	0	0	0	0	0
Lincomycin	-	-	-	-	-	-
Neomycin	4/39 (10.3)	0	1/12 (8.3)	7/17 (41.2)	5/14 (35.7)	2/22 (9.1)
Spectinomycin	1/39 (2.6)	0	0	6/17 (35.3)	4/14 (28.6)	2/22 (9.1)
Streptomycin	3/24 (12.5)	3/27 (11.1)	2/11 (18.2)	5/15 (33.3)	5/14 (35.7)	2/22 (9.1)
Tetracycline	33/39 (84.6)	27/33 (81.8)	8/12 (66.7)	6/17 (35.3)	4/14 (28.6)	8/22 (36.4)
Trimethoprim/Sulphonamide	9/39 (23.1)	11/33 (33.3)	1/12 (8.3)	5/17 (29.4)	0	9/22 (40.9)
Tylosin	4/24 (16.7)	1/28 (3.6)	3/11 (27.3)	8/15 (53.3)	13/14 (92.9)	20/22 (90.9)

Annex 14: Clinical surveillance data for isolates from respiratory infections of sheep

Table A14.1: Resistance (interpreted using BSAC CBPs) of *Pasteurella multocida* and *Mannheimia haemolytica* from sheep, 2013-2015

	No. resistant / No. tested (Percentage resistant)					
	Sheep, P. multocida			*Sheep, M. haemolytica*		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amoxicillin/Clavulanic acid	0	0	0	0	0	0
Ampicillin	0	0	1/3 (33.3)	0	0	0
Cefalexin	-	-	-	-	-	-
Cefpodoxime	0	0	0	0	0	0
Enrofloxacin	0	0	0	0	0	0
Florfenicol	0	0	0	0	0	0
Tetracycline	1/5 (20)	0	0	0	2/24 (8.3)	1/35 (2.9)
Trimethoprim/Sulphonamide	0	0	0	0	1/24 (4.2)	1/35 (2.9)
Tylosin	-	-	-	-	-	-

Table A14.2: Resistance (interpreted using BSAC CBPs) of *Bibersternia trehalosi* and *Trueperella pyogenes* from sheep, 2013-2015

	No. resistant / No. tested (Percentage resistant)					
	Sheep, B. trehalosi			*Sheep, T. pyogenes*		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amoxicillin/Clavulanic acid	0	0	0	0	0	0
Ampicillin	0	0	0	0	0	0
Cefalexin	-	-	-	0	0	0
Cefpodoxime	0	0	0	-	-	-
Enrofloxacin	0	0	0	-	-	-
Florfenicol	0	0	0	0	0	0
Tetracycline	1/18 (5.6)	0	1/40 (2.5)	2/5 (40)	2/10 (20)	0
Trimethoprim/Sulphonamide	0	0	1/40 (2.5)	0	4/9 (44.4)	0
Tylosin	-	-	-	0	0	0

Annex 15: 'Other Veterinary Pathogens'

Table A15.1: MIC values of *Brachyspira hyodysenteriae* isolates from infections of pigs to tiamulin, 2010-2015

	MIC								
Year	**<0.06**	**0.12**	**0.25**	**0.5**	**1**	**2**	**4**	**8**	**>8**
2010	10	1	-	1	1	-	-	-	-
2011	10	-	-	-	-	2	-	-	-
2012	2	-	2	-	-	2	1	-	2
2013	-	-	1	2	1	-	1	-	3
2014	-	-	-	-	-	2	-	1	1
2015	-	-	3	-	-	1	-	1	-

Table A15.2: Resistance (interpreted using BSAC CBPs) of *Streptococcus suis* from infections of pigs, 2013-2015

	No. (%) of isolates resistant		
	Pigs, *S. suis*		
Antibiotic	**2013** (n=55)	**2014** (n=64)	**2015** (n=63)
Ampicillin	0	0	0
Penicillin	1 (1.8%)	0	0
Cefalexin	-	-	-
Enrofloxacin	0	0	0
Lincomycin	25 (45.5%)	21 (32.8%)	26 (41.3%)
Tetracycline	52 (94.5%)	61 (95.3%)	59 (93.7%)
Trimethoprim/Sulphonamide	7 (12.7%)	15 (23.4%)	14 (22.2%)
Tylosin	26 (47.3%)	24 (37.5%)	37 (58.7%)

Table A15.3: Resistance (interpreted using BSAC CBPs) of *Staphylococcus aureus* from infections of chickens, 2013-2015

	No. (%) of isolates resistant		
	Chickens, *S. aureus*		
Antibiotic	**2013** (n=26)	**2014** (n=26)	**2015** (n=8)
Amoxicillin/Clavulanic acid	0	0	0
Ampicillin	0	0	0
Doxycycline	3 (11.5%)	2 (7.7%)	0
Enrofloxacin	1 (3.8%)	0	0
Erythromycin	2 (8%)	2 (8%)	1 (12.5%)
Lincomycin	2 (7.7%)	2 (7.7%)	1 (12.5%)
Tetracycline	3 (11.5%)	3 (11.5%)	1 (12.5%)
Trimethoprim/Sulphonamide	0	0	0
Tylosin	1 (3.8%)	0	0

Note: Only 25 S. aureus were tested for susceptibility to amoxicillin/clavulanic acid and erythromycin in 2013 and 2014

Table A15.4: Resistance (interpreted using BSAC CBPs) of *Erysipelothrix rhusiopathiae* from infections of pigs, 2013-2015

	No. (%) of isolates resistant		
	Pigs, *E. rhusiopathiae*		
Antibiotic	**2013** (n=11)	**2014** (n=11)	**2015** (n=6)
Amoxicillin/Clavulanic acid	-	-	-
Ampicillin	0	0	0
Enrofloxacin	0	1 (9.1%)	0
Lincomycin	0	0	0
Tetracycline	4 (36.4%)	3 (27.3%)	2 (33.3%)
Trimethoprim/Sulphonamide	8 (72.7%)	2 (18.2%)	2 (33.3%)
Tylosin	0	0	0

Table A15.5: Resistance (interpreted using BSAC CBPs) of *Listeria monocytogenes* from infections of sheep, 2013-2015

	No. (%) of isolates resistant		
	Sheep, *Listeria monocytogenes*		
Antibiotic	**2013** (n=10)	**2014** (n=2)	**2015** (n=4)
Amoxicillin/Clavulanic acid	0	0	0
Ampicillin	0	0	0
Cefalexin	3 (30%)	0	3 (75%)
Florfenicol	0	0	0
Tetracycline	0	1 (50%)	0
Trimethoprim/Sulphonamide	0	0	0
Tylosin	0	0	0

Table A15.6: Resistance (interpreted using BSAC CBPs) of *Streptococcus dysgalactiae* from infections of sheep, 2013-2015

	No. (%) of isolates resistant		
	Sheep, *Streptococcus dysgalactiae*		
Antibiotic	**2013** (n=26)	**2014** (n=14)	**2015** (n=18)
Amoxicillin/Clavulanic acid	0	0	0
Ampicillin	0	0	0
Cefalexin	0	0	0
Florfenicol	0	0	0
Tetracycline	22 (84.6%)	14 (100%)	18 (100%)
Trimethoprim/Sulphonamide	0	0	0
Tylosin	1 (3.8%)	3 (21.4%)	0

Note: Only 11, 7, and 4 S. dysgalactiae were tested for susceptibility to florfenicol and trimethoprim/sulphonamide in 2013, 2014, and 2015, respectively

Annex 16: Clinical surveillance data for *E. coli*

Table A16.1 – Resistance in all *E. coli* from cattle, sheep, pigs, chickens and turkeys (combined) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	4/856 (0.5)	2/590 (0.3)	3/524 (0.6)	-	-	-	-	-	-
Amoxi/Clav	447/1296 (34.5)	314/1045 (30)	282/1034 (27.3)	756/1304 (58)	496/986 (50.3)	471/931 (50.6)	95/336 (28.3)	72/293 (24.6)	69/346 (19.9)
Ampicillin	892/1400 (63.7)	733/1144 (64.1)	713/1101 (64.8)	992/1304 (76.1)	798/986 (80.9)	748/931 (80.3)	158/336 (47)	136/293 (46.4)	130/346 (37.6)
Apramycin	85/1360 (6.3)	73/1118 (6.5)	60/1073 (5.6)	212/1304 (16.3)	116/980 (11.8)	138/917 (15)	7/248 (2.8)	3/236 (1.3)	3/271 (1.1)
Cefotaxime	98/857 (11.4)	80/593 (13.5)	49/526 (9.3)	-	-	-	0	0	0
Cefpodoxime	27/434 (6.2)	19/481 (4)	34/474 (7.2)	819/1304 (62.8)	396/980 (40.4)	403/912 (44.2)	15/247 (6.1)	12/236 (5.1)	8/271 (3)
Ceftazidime	53/857 (6.2)	44/593 (7.4)	34/526 (6.5)	-	-	-	0	0	-
Chloramphenicol	440/856 (51.4)	298/590 (50.5)	244/524 (46.6)	-	-	-	0	0/2 (0)	0/1 (0)
Doxycycline	86/371 (23.2)	157/452 (34.7)	132/451 (29.3)	-	-	-	0	-	-
Enrofloxacin	114/1400 (8.1)	93/1144 (8.1)	118/1101 (10.7)	647/1304 (49.6)	418/986 (42.4)	414/931 (44.5)	24/337 (7.1)	13/293 (4.4)	12/346 (3.5)
Florfenicol	295/969 (30.4)	209/764 (27.4)	174/709 (24.5)	669/1304 (51.3)	448/919 (48.7)	413/878 (47)	36/240 (15)	33/223 (14.8)	28/257 (10.9)
Neomycin	398/1282 (31)	287/1049 (27.4)	266/1030 (25.8)	1304/1304 (100)	986/986 (100)	932/932 (100)	44/331 (13.3)	26/293 (8.9)	26/346 (7.5)
Spectinomycin	565/1360 (41.5)	441/1118 (39.4)	462/1073 (43.1)	-	-	-	72/248 (29)	56/236 (23.7)	60/271 (22.1)
Streptomycin	556/933 (59.6)	442/742 (59.6)	443/685 (64.7)	-	-	-	8/89 (9)	7/55 (12.7)	2/73 (2.7)
Tetracycline	932/1400 (66.6)	779/1144 (68.1)	708/1101 (64.3)	1071/1304 (82.1)	770/986 (78.1)	745/927 (80.4)	175/337 (51.9)	169/293 (57.7)	160/346 (46.2)
Trimetho/Sulpho	508/1400 (36.3)	442/1144 (38.6)	420/1101 (38.1)	874/1304 (67)	629/986 (63.8)	615/926 (66.4)	85/335 (25.4)	76/293 (25.9)	64/346 (18.5)

Table A16.2 – Resistance in all *E. coli* from cattle (all ages) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	4/706 (0.6)	2/492 (0.4)	2/441 (0.5)	-	-	-	-	-	-
Amoxi/Clav	385/780 (49.4)	271/533 (50.8)	223/494 (45.1)	683/1060 (64)	424/733 (58)	443/714 (62)	75/183 (41)	61/146 (41.8)	44/150 (29.3)
Ampicillin	617/780 (79.1)	431/533 (80.9)	392/494 (79.4)	936/1057 (89)	630/732 (86)	602/714 (84)	91/184 (49.5)	76/146 (52.1)	58/150 (38.7)
Apramycin	50/761 (6.6)	22/517 (4.3)	22/480 (4.6)	186/1060 (18)	83/729 (11)	105/709 (15)	2/96 (2.1)	2/90 (2.2)	2/77 (2.6)
Cefotaxime	94/707 (13.3)	77/495 (15.6)	46/443 (10.4)	-	-	-	-	-	-
Cefpodoxime	-	-	-	703/1059 (66)	308/731 (42)	328/704 (47)	9/96 (9.4)	12/90 (13.3)	0/78 (0)
Ceftazidime	52/707 (7.4)	42/495 (8.5)	32/443 (7.2)	-	-	-	-	-	-
Chloramphenicol	386/706 (54.7)	271/492 (55.1)	228/441 (51.7)	-	-	-	-	0/1 (0)	-
Doxycycline	-	-	-	-	-	-	-	-	-
Enrofloxacin	93/780 (11.9)	60/533 (11.3)	58/494 (11.7)	583/1059 (55)	368/732 (50)	361/714 (51)	20/184 (10.9)	11/146 (7.5)	6/150 (4)
Florfenicol	262/724 (36.2)	190/507 (37.5)	147/455 (32.3)	615/1059 (58)	416/728 (57)	402/712 (56)	33/95 (34.7)	32/90 (35.6)	22/77 (28.6)
Neomycin	332/761 (43.6)	250/517 (48.4)	217/480 (45.2)	1058/1058 (100)	732/732 (100)	714/714 (100)	38/179 (21.2)	21/146 (14.4)	20/150 (13.3)
Spectinomycin	380/761 (49.9)	231/517 (44.7)	218/480 (45.4)	-	-	-	44/96 (45.8)	34/90 (37.8)	29/77 (37.7)
Streptomycin	439/706 (62.2)	316/492 (64.2)	315/441 (71.4)	-	-	-	7/88 (8)	7/55 (12.7)	1/72 (2.4)
Tetracycline	595/780 (76.3)	424/533 (79.5)	369/494 (74.7)	910/1060 (86)	597/732 (82)	593/711 (83)	106/184 (57.6)	81/146 (55.5)	65/150 (43.3)
Trimetho/Sulph	359/780 (46)	261/533 (49)	224/494 (45.3)	758/1060 (72)	503/732 (69)	505/711 (71)	45/182 (24.7)	43/146 (29.5)	26/150 (17.3)

Table A16.3 – Resistance in all *E. coli* from pigs (all ages) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	-	-	-	-	-	-	-	-	-
Amoxi/Clav	3/76 (3.9)	6/151 (4)	8/159 (5)	26/85 (31)	33/101 (33)	21/93 (23)	1/8 (12.5)	3/11 (27.3)	5/22 (22.7)
Ampicillin	51/101 (50.5)	104/180 (57.8)	102/182 (56)	65/84 (77)	71/101 (70)	67/93 (72)	2/8 (25)	6/11 (54.5)	6/22 (27.3)
Apramycin	14/101 (13.9)	34/180 (18.9)	31/182 (17)	11/85 (13)	20/100 (20)	20/93 (22)	1/8 (12.5)	0/11 (0)	0/22 (0)
Cefotaxime	-	-	-	-	-	-	-	-	-
Cefpodoxime	4/101 (4)	7/180 (3.9)	3/182 (1.6)	42/85 (49)	28/100 (28)	26/93 (28)	0/8 (0)	0/11 (0)	0/21 (0)
Ceftazidime	-	-	-	-	-	-	-	-	-
Chloramphenicol	-	-	-	-	-	-	-	-	-
Doxycycline	45/76 (59.2)	90/151 (59.6)	79/159 (49.7)	-	-	-	-	-	-
Enrofloxacin	8/101 (7.9)	17/180 (9.4)	7/182 (3.8)	34/85 (40)	23/101 (23)	28/93 (30)	1/8 (12.5)	0/11 (0)	2/22 (9.1)
Florfenicol	5/76 (6.6)	8/151 (5.3)	16/159 (10.1)	24/85 (28)	12/100 (12)	12/93 (13)	1/8 (12.5)	0/11 (0)	1/22 (4.5)
Neomycin	10/101 (9.9)	7/180 (3.9)	15/182 (8.2)	85/85 (100)	101/101 (100)	93/93 (100)	1/8 (12.5)	0/11 (0)	0/22 (0)
Spectinomycin	34/101 (33.7)	86/180 (47.8)	78/182 (42.9)	-	-	-	2/8 (25)	5/11 (45.4)	3/22 (13.6)
Streptomycin	33/76 (43.4)	82/151 (54.3)	71/159 (44.7)	-	-	-	0	0	0
Tetracycline	75/101 (74.3)	142/180 (78.9)	121/182 (66.5)	66/85 (78)	81/101 (80)	76/93 (82)	5/8 (62.5)	8/11 (72.7)	9/22 (40.9)
Trimetho/Sulph	51/101 (50.5)	102/180 (56.7)	99/182 (54.4)	68/85 (80)	79/101 (78)	70/92 (76)	3/8 (37.5)	6/11 (54.5)	3/22 (13.6)

Table A16.4 – Resistance in all *E. coli* from sheep (all ages) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	0/150 (0)	0/98 (0)	1/83 (1.2)	-	-	-	-	-	-
Amoxi/Clav	48/224 (21.4)	26/130 (20)	21/133 (15.8)	31/98 (32)	23/83 (28)	24/66 (36)	10/45 (22.2)	8/29 (27.6)	11/48 (22.9)
Ampicillin	125/224 (55.8)	71/130 (54.6)	74/133 (55.6)	72/98 (73)	60/83 (72)	44/66 (67)	18/44 (40.9)	11/29 (37.9)	19/48 (39.6)
Apramycin	3/204 (1.5)	3/120 (2.5)	1/119 (0.8)	8/98 (8)	8/83 (10)	7/66 (11)	0/44 (0)	0/28 (0)	1/46 (2.2)
Cefotaxime	4/150 (2.7)	3/98 (3.1)	3/83 (3.6)	-	-	-	-	-	-
Cefpodoxime	-	-	-	43/98 (44)	30/83 (36)	25/66 (38)	0/43 (0)	0/28 (0)	0/46 (0)
Ceftazidime	1/150 (0.7)	2/98 (2)	2/83 (2.4)	-	-	-	-	-	-
Chloramphenicol	54/150 (36)	27/98 (27.6)	16/83 (19.3)	-	-	-	-	0/1 (0)	0/1 (0)
Doxycycline	-	-	-	-	-	-	-	-	-
Enrofloxacin	8/224 (3.6)	1/130 (0.8)	2/133 (1.5)	18/98 (18)	18/83 (22)	11/66 (17)	0/45 (0)	0/29 (0)	2/48 (3.6)
Florfenicol	28/169 (16.6)	11/106 (10.4)	11/95 (11.6)	27/97 (28)	19/83 (23)	19/66 (29)	1/44 (2.3)	1/28 (3.6)	5/44 (11.4)
Neomycin	36/205 (17.6)	9/121 (7.4)	21/121 (17.4)	98/98 (100)	83/83 (100)	66/66 (100)	3/44 (6.8)	4/29 (13.8)	4/48 (8.3)
Spectinomycin	108/204 (52.9)	52/120 (43.3)	67/119 (56.3)	-	-	-	13/44 (29.5)	7/28 (25)	13/46 (28.3)
Streptomycin	84/151 (55.6)	44/99 (44.4)	57/85 (67.1)	-	-	-	1/1 (100)	0	1/1 (100)
Tetracycline	153/224 (68.3)	89/130 (68.5)	86/133 (64.7)	70/97 (72)	60/83 (72)	48/66 (72)	24/45 (53.3)	18/29 (62.1)	26/48 (54.2)
Trimetho/Sulph	62/224 (27.7)	28/130 (21.5)	36/133 (27.1)	40/98 (41)	32/83 (39)	22/66 (33)	7/45 (15.6)	7/29 (24.1)	7/48 (14.6)

Table A16.5 – Resistance in all *E. coli* from chickens (all ages) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	-	-	-	-	-	-	-	-	-
Amoxi/Clav	11/215 (5.1)	11/230 (4.8)	30/248 (12.1)	8/22 (36)	3/33 (9)	5/25 (20)	8/93 (8.6)	0/94 (0)	9/114 (7.9)
Ampicillin	94/289 (32.5)	124/294 (42.2)	143/287 (49.8)	12/22 (55)	16/33 (48)	18/26 (72)	44/93 (47.3)	32/94 (34)	38/114 (33.3)
Apramycin	18/288 (6.3)	14/294 (4.8)	6/287 (2.1)	5/22 (23)	1/33 (3)	2/26 (8)	4/93 (4.3)	1/94 (1.1)	0/114 (0)
Cefotaxime	-	-	-	-	-	-	-	-	-
Cefpodoxime	23/288 (8)	12/294 (4.1)	31/287 (10.8)	18/22 (82)	14/33 (42)	14/26 (54)	6/93 (6.5)	0/94 (0)	8/114 (7)
Ceftazidime	-	-	-	-	-	-	-	-	-
Chloramphenicol	-	-	-	-	-	-	-	-	-
Doxycycline	40/289 (13.8)	65/294 (22.1)	49/287 (17.1)	-	-	-	-	-	-
Enrofloxacin	5/289 (1.7)	14/294 (4.8)	50/287 (17.4)	5/22 (23)	3/33 (9)	6/26 (23)	3/93 (3.2)	1/94 (1.1)	1/114 (0.9)
Florfenicol	-	-	-	-	-	-	1/93 (1.1)	0/94 (0)	0/114 (0)
Neomycin	20/214 (9.3)	21/230 (9.1)	13/247 (5.3)	22/22 (100)	33/33 (100)	26/26 (100)	2/93 (2.2)	1/94 (1.1)	2/114 (1.8)
Spectinomycin	43/288 (14.9)	71/294 (24.1)	99/287 (34.5)	-	-	-	13/93 (14)	9/94 (9.6)	14/114 (12.3)
Streptomycin	-	-	-	-	-	-	-	-	-
Tetracycline	104/289 (36)	120/294 (40.8)	128/287 (44.6)	9/22 (41)	12/33 (36)	13/26 (50)	37/93 (39.8)	52/94 (55.3)	52/114 (45.6)
Trimetho/Sulph	36/289 (12.5)	50/294 (17)	60/287 (20.9)	5/22 (23)	5/33 (15)	7/26 (27)	30/93 (32.3)	18/94 (19.1)	20/114 (17.5)

Table A16.6 – Resistance in all *E. coli* from turkeys (all ages) in England & Wales, Northern Ireland and Scotland

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Amikacin	-	-	-	-	-	-	-	-	-
Amoxi/Clav	0/1 (0)	0/1 (0)	-	0	2/7 (29)	1/3 (33)	1/7 (14.3)	0/13 (0)	0/12 (0)
Ampicillin	5/6 (83.3)	3/7 (42.9)	2/5 (40)	0	5/7 (71)	2/3 (66)	3/7 (42.9)	11/13 (84.6)	9/12 (75)
Apramycin	0/6 (0)	0/7 (0)	0/5 (0)	0	0/7 (0)	1/3 (33)	0/7 (0)	0/13 (0)	0/12 (0)
Cefotaxime	-	-	-	-	-	-	-	-	-
Cefpodoxime	0/6 (0)	0/7 (0)	0/5 (0)	0	2/7 (29)	2/3 (66)	0/7 (0)	0/13 (0)	0/12 (0)
Ceftazidime	-	-	-	-	-	-	-	-	-
Chloramphenicol	-	-	-	-	-	-	-	-	-
Doxycycline	1/6 (16.7)	2/7 (28.6)	4/5 (80)	-	-	-	-	-	-
Enrofloxacin	0/6 (0)	1/7 (14.3)	1/5 (20)	0	1/7 (0.1)	-	0/7 (0)	1/13 (7.7)	1/12 (8.3)
Florfenicol	-	-	-	-	-	-	0	0	0
Neomycin	0/1 (0)	0/1 (0)	-	0	7/7 (100)	3/3 (100)	0/7 (0)	0/13 (0)	0/12 (0)
Spectinomycin	0/6 (0)	1/7 (14.3)	0/5 (0)	-	-	-	0/7 (0)	1/13 (7.7)	1/12 (8.3)
Streptomycin	-	-	-	-	-	-	-	-	-
Tetracycline	5/6 (83.3)	4/7 (57.1)	4/5 (80)	0	6/7 (86)	2/3 (66)	3/7 (42.9)	10/13 (76.9)	8/12 (66.7)
Trimetho/Sulph	0/6 (0)	1/7 (14.3)	1/5 (20)	0	2/7 (29)	2/3 (66)	0/7 (0)	2/13 (7.7)	8/12 (66.7)

Table A16.7 – Resistance in *E. coli* from cattle in England & Wales, Northern Ireland and Scotland in 2013

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**
Amikacin	3/599 (0.5)	0/61 (0)	0/3 (0)	-	-	-	0	0	0
Amoxi/Clav	330/629 (52.5)	36/86 (41.9)	2/16 (12.5)	334/497 (67)	_	_	42/129 (32.6)	30/39 (76.9)	3/14 (21.4)
Ampicillin	511/629 (81.2)	69/86 (80.2)	5/16 (31.3)	452/497 (91)	_	_	54/130 (41.5)	33/39 (84.6)	4/14 (28.5)
Apramycin	39/621 (6.3)	5/78 (6.4)	1/14 (7.1)	98/497 (20)	_	_	0/54 (0)	1/39 (2.6)	1/2 (50)
Cefotaxime	75/599 (12.5)	12/61 (19.7)	0/4 (0)	-	_	_	0	0	0
Ceftazidime	46/599 (7.7)	4/61 (6.6)	0/4 (0)	-	_	_	0	0	0
Chloramphenicol	333/599 (55.6)	34/61 (55.7)	2/3 (66.7)	-	_	_	0	0	0
Enrofloxacin	75/629 (11.9)	9/86 (10.5)	2/16 (12.5)	245/497 (49)	_	_	11/130 (8.5)	7/39 (17.9)	2/14 (14.3)
Florfenicol	215/606 (35.5)	33/69 (47.8)	1/5 (20)	241/497 (48)	_	_	15/54 (27.8)	18/39 (46.2)	0/1 (0)
Neomycin	276/621 (44.4)	38/78 (48.7)	1/14 (7.1)	496/496 (100)	_	_	22/125 (17.6)	14/39 (35.9)	2/14 (14.3)
Spectinomycin	329/621 (53)	28/78 (35.9)	4/14 (28.6)	-	_	_	24/54 (44.4)	20/39 (51.3)	0/2 (0)
Streptomycin	372/599 (62.1)	43/61 (70.5)	2/3 (66.7)	-	_	_	3/76 (3.9)	0	4/12 (33.3)
Tetracycline	489/629 (77.7)	67/86 (77.9)	7/16 (43.8)	226/497 (45)	_	_	64/130 (49.2)	35/39 (89.7)	6/14 (42.9)
Trim/Sulpho	290/629 (46.1)	46/86 (53.5)	4/16 (25)	224/497 (45)	_	_	25/130 (19.2)	17/37 (45.9)	3/14 (21.4)

Table A16.8 – Resistance in *E. coli* from cattle in England & Wales, Northern Ireland and Scotland in 2014

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**
Amikacin	2/432 (0.5)	0/28 (0)	0/3 (0)	-	-	-	0	0	0
Amoxi/Clav	231/449 (51.4)	20/44 (45.5)	2/8 (25)	207/321 (64)	_	_	35/103 (34)	25/37 (67.6)	1/5 (20)
Ampicillin	365/449 (81.3)	32/44 (72.7)	6/8 (75)	287/321 (89)	_	_	46/103 (44.7)	28/37 (75.7)	2/5 (40)
Apramycin	20/442 (4.5)	2/37 (5.4)	0/7 (0)	43/320 (13)	_	_	1/52 (1.9)	1/37 (2.7)	0
Cefotaxime	64/432 (14.8)	7/28 (25)	4/6 (66.7)	-	_	_	0	0	0
Ceftazidime	32/432 (7.4)	5/28 (17.9)	3/6 (50)	-	_	_	0	0	0
Chloramphenicol	237/432 (54.9)	12/28 (42.9)	3/3 (100)	-	_	_	1/1 (100)	0	0
Enrofloxacin	52/449 (11.6)	4/44 (9.1)	2/8 (25)	163/321 (51)	_	_	5/103 (4.9)	6/37 (16.2)	0/5 (0)
Florfenicol	163/439 (37.1)	10/35 (28.6)	2/3 (66.7)	187/320 (58)	_	_	14/52 (26.9)	18/37 (48.6)	0
Neomycin	218/442 (49.3)	18/37 (48.6)	1/7 (14.3)	321/321 (100)	_	_	11/103 (10.7)	10/37 (27)	0/5 (0)
Spectinomycin	204/442 (46.2)	11/37 (29.7)	1/7 (14.3)	-	_	_	18/52 (34.6)	16/37 (43.2)	0
Streptomycin	278/432 (64.4)	14/28 (50)	2/3 (66.7)	-	_	_	7/50 (14)	0	0/5 (0)
Tetracycline	357/449 (79.5)	37/44 (84.1)	5/8 (62.5)	260/321 (81)	_	_	45/103 (43.7)	33/37 (89.2)	2/5 (40)
Trim/Sulpho	217/449 (48.3)	22/44 (50)	3/8 (37.5)	223/321 (69)	_	_	23/103 (22.3)	19/37 (51.4)	1/5 (20)

Table A16.9 – Resistance in *E. coli* from cattle in England & Wales, Northern Ireland and Scotland in 2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Pre-weaning**	**Adult**
Amikacin	2/352 (0.6)	0/59 (0)	0/7 (0)	-	-	-	0	0	0
Amoxi/Clav	181/376 (48.1)	23/75 (30.7)	5/15 (33.3)	201/331 (61)	_	_	28/114 (24.6)	15/30 (50)	1/6 (16.7)
Ampicillin	310/376 (82.4)	52/75 (69.3)	10/15 (66.7)	296/331 (89)	_	_	40/114 (35.1)	16/30 (1.9)	2/6 (33.3)
Apramycin	12/369 (3.3)	8/73 (11)	1/13 (7.7)	34/329 (10)	_	_	2/45 (4.4)	0/30 (0)	0/2 (0)
Cefotaxime	37/352 (10.5)	3/59 (5.1)	2/9 (22.2)	-	_	_	0	0	0
Ceftazidime	28/352 (8)	2/59 (3.4)	1/9 (11.1)	-	_	_	0	0	0
Chloramphenicol	174/352 (49.4)	35/59 (59.3)	3/7 (42.9)	-	_	_	0	0	0
Enrofloxacin	38/376 (10.1)	11/75 (14.7)	4/15 (26.7)	167/331 (50)	_	_	2/114 (1.8)	4/30 (7.5)	0/6 (0)
Florfenicol	105/359 (29.2)	25/61 (41)	3/9 (33.3)	187/331 (56)	_	_	10/45 (22.2)	12/30 (2.5)	0/2 (0)
Neomycin	161/369 (43.6)	39/73 (53.4)	6/13 (46.2)	331/331 (100)	_	_	11/114 (9.6)	8/30 (3.75)	1/6 (16.7)
Spectinomycin	173/369 (46.9)	29/73 (39.7)	4/13 (30.8)	-	_	_	20/45 (44.4)	8/30 (3.75)	1/2 (50)
Streptomycin	250/352 (71)	46/59 (78)	4/7 (57.1)	-	_	_	1/68 (1.5)	0	0/4 (0)
Tetracycline	284/376 (75.5)	55/75 (73.3)	11/15 (73.3)	284/331 (86)	_	_	46/114 (40.4)	18/30 (1.7)	1/6 (16.7)
Trim/Sulpho	168/376 (44.7)	34/75 (45.3)	7/15 (46.7)	245/331 (74)	_	_	17/114 (14.9)	9/30 (3.3)	0/6 (0)

Table A16.10 – Resistance in *E. coli* from pigs in England & Wales, Northern Ireland and Scotland in 2013

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Post-weaning**	**Adult**
Amoxi/Clav	1/18 (5.6)	2/31 (6.5)	0/4 (0)	10/25 (40)	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Ampicillin	16/28 (57.1)	20/35 (57.1)	3/6 (50)	22/25 (88)	-	-	1/2 (50)	1/4 (25)	0/1 (0)
Apramycin	0/28 (0)	9/35 (25.7)	1/6 (16.7)	4/25 (16)	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Cefpodoxime	1/28 (3.6)	1/35 (2.9)	0/6 (0)	17/25 (68)	-	-	0/2 (0)	0/4 (0)	0
Doxycycline	11/18 (61.1)	20/31 (64.5)	1/4 (25)	-	-	-	0	0	0
Enrofloxacin	3/28 (10.7)	2/35 (5.7)	0/6 (0)	13/25 (52)	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Florfenicol	0/18 (0)	4/31 (12.9)	0/4 (0)	4/25 (16)	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Neomycin	2/28 (7.1)	5/35 (14.3)	1/6 (16.7)	25/25 (100)	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Spectinomycin	9/28 (32.1)	17/35 (48.6)	1/6 (16.7)	-	-	-	0/2 (0)	1/4 (25)	0/1 (0)
Streptomycin	9/18 (50)	16/31 (51.6)	0/4 (0)	-	-	-	0	0	0
Tetracycline	18/28 (64.3)	26/35 (74.3)	4/6 (66.7)	22/25 (88)	-	-	2/2 (100)	3/4 (75)	0/1 (0)
Trimetho/Sulph	14/28 (50)	21/35 (60)	2/6 (33.3)	21/25 (84)	-	-	1/2 (50)	1/4 (25)	0/1 (0)

Table A16.11 – Resistance in *E. coli* from pigs in England & Wales, Northern Ireland and Scotland in 2014

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Post--weaning**	**Adult**	**Neonatal**	**Post--weaning**	**Adult**
Amoxi/Clav	0/25 (0)	3/78 (3.8)	0/6 (0)	11/43 (26)	-	-	2/7 (28.6)	0/1 (0)	0/1 (0)
Ampicillin	19/39 (48.7)	51/84 (60.7)	3/7 (42.9)	28/43 (65)	-	-	3/7 (42.9)	0/1 (0)	1/1 (100)
Apramycin	1/39 (2.6)	31/84 (36.9)	0/7 (0)	8/43 (19)	-	-	0/7 (0)	0/1 (0)	0/1 (0)
Cefpodoxime	0/39 (0)	1/84 (1.2)	0/7 (0)	9/43 (21)	-	-	0/7 (0)	0/1 (0)	0
Doxycycline	12/25 (48)	51/78 (65.4)	3/6 (50)	-	-	-	0	0	0
Enrofloxacin	7/39 (17.9)	5/84 (6)	1/7 (14.3)	10/43 (23)	-	-	0/7 (0)	0/1 (0)	0/1 (0)
Florfenicol	1/25 (4)	4/78 (5.1)	0/6 (0)	9/43 (21)	-	-	0/7 (0)	0/1 (0)	0/1 (0)
Neomycin	2/39 (5.1)	2/84 (2.4)	1/7 (14.3)	43/43 (100)	-	-	0/7 (0)	0/1 (0)	0/1 (0)
Spectinomycin	20/39 (51.3)	44/84 (52.4)	3/7 (42.9)	-	-	-	3/7 (42.9)	1/1 (100)	0/1 (0)
Streptomycin	10/25 (40)	49/78 (62.8)	3/6 (50)	-	-	-	0	0	0
Tetracycline	30/39 (76.9)	69/84 (82.1)	5/7 (71.4)	33/43 (77)	-	-	5/7 (71.4)	1/1 (100)	0/1 (0)
Trimetho/Sulph	19/39 (48.7)	54/84 (64.3)	2/7 (28.6)	40/43 (93)	-	-	3/7 (42.9)	1/1 (100)	0/1 (0)

Table A16.12 – Resistance in *E. coli* from pigs in England & Wales, Northern Ireland and Scotland in 2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Post--weaning**	**Adult**	**Neonatal**	**Post--weaning**	**Adult**
Amoxi/Clav	2/30 (6.7)	4/93 (4.3)	1/7 (14.3)	10/47 (21)	-	-	1/5 (20)	3/15 (20)	1/1 (100)
Ampicillin	18/39 (46.2)	63/97 (64.9)	3/7 (42.9)	36/47 (77)	-	-	1/5 (20)	4/15 (26.7)	1/1 (100)
Apramycin	0/39 (0)	25/97 (25.8)	0/7 (0)	10/47 (21)	-	-	0/5 (0)	0/15 (0)	1/1 (0)
Cefpodoxime	0/39 (0)	2/97 (2.1)	0/7 (0)	9/47 (19)	-	-	0/5 (0)	0/15 (0)	0
Doxycycline	13/30 (43.3)	51/93 (54.8)	2/7 (28.6)	-	-	-	0	0	0
Enrofloxacin	1/39 (2.6)	5/97 (5.2)	0/7 (0)	16/47 (34)	-	-	0/5 (0)	2/15 (13.3)	0/1 (0)
Florfenicol	1/30 (3.3)	13/93 (14)	1/7 (14.3)	4/47 (9)	-	-	0/5 (0)	0/15 (0)	1/1 (100)
Neomycin	1/39 (2.6)	12/97 (12.4)	0/7 (0)	47/47 (100)	-	-	0/5 (0)	0/15 (0)	0/1 (0)
Spectinomycin	15/39 (38.5)	48/97 (49.5)	2/7 (28.6)	-	-	-	0/5 (0)	0/15 (0)	0/1 (0)
Streptomycin	10/30 (33.3)	45/93 (48.4)	4/7 (57.1)	-	-	-	0	0	0
Tetracycline	28/39 (71.8)	67/97 (69.1)	3/7 (42.9)	40/47 (85)	-	-	3/5 (60)	5/15 (33.3)	1/1 (100)
Trimetho/Sulph	17/39 (43.6)	63/97 (64.9)	3/7 (42.9)	37/47 (78)	-	-	0/5 (0)	3/15 (20)	0/1 (0)

Table A16.13 – Resistance in E. coli from sheep in England & Wales, Northern Ireland and Scotland in 2013

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Pre--weaning**	**Adult**
Amoxi/Clav	44/173 (25.4)	2/15 (13.3)	0/18 (0)	1/6 (17)	-	-	5/28 (17.9)	4/12 (33.3)	1/3 (33.3)
Ampicillin	108/173 (62.4)	4/15 (26.7)	6/18 (33.3)	6/18 (33.3)	-	-	10/27 (37)	5/12 (41.7)	3/3 (100)
Apramycin	3/170 (1.8)	0/10 (0)	0/9 (0)	0/9 (0)	-	-	0/27 (0)	0/12 (0)	0/3 (0)
Cefotaxime	4/139 (2.9)	0/3 (0)	0/1 (0)	0/1 (0)	-	-	0	0	0
Ceftazidime	1/139 (0.7)	0/3 (0)	0/1 (0)	0/1 (0)	-	-	0	0	0
Chloramphenicol	50/139 (36)	2/3 (66.7)	0/1 (0)	0/1 (0)	-	-	0	0	0
Enrofloxacin	6/173 (3.5)	0/15 (0)	1/18 (5.6)	1/18 (5.6)	-	-	0/28 (0)	0/12 (0)	0/3 (0)
Florfenicol	24/142 (16.9)	2/8 (25)	0/10 (0)	0/10 (0)	-	-	0/27 (0)	1/12 (8.3)	0/3 (0)
Neomycin	33/170 (19.4)	2/10 (20)	0/9 (0)	0/9 (0)	-	-	1/28 (3.6)	2/11 (18.2)	0/3 (0)
Spectinomycin	101/170 (59.4)	2/10 (20)	2/9 (22.2)	2/9 (22.2)	-	-	9/27 (33.3)	3/12 (25)	1/3 (33.3)
Streptomycin	77/139 (55.4)	2/3 (66.7)	1/1 (100)	1/1 (100)	-	-	1/1 (100)	0	0
Tetracycline	130/173 (75.1)	9/15 (60)	7/18 (38.9)	7/18 (38.9)	-	-	12/28 (42.9)	10/12 (83.3)	2/3 (66.7)
Trimetho/Sulph	54/173 (31.2)	4/15 (26.7)	2/18 (11.1)	2/18 (11.1)	-	-	5/28 (17.9)	1/12 (8.3)	1/3 (33.3)

Table A16.14 – Resistance in *E. coli* from sheep in England & Wales, Northern Ireland and Scotland in 2014

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Post-weaning**	**Adult**	**Neonatal**	**Pre--weaning**	**Adult**
Amoxi/Clav	23/105 (21.9)	0/12 (0)	1/5 (20)	3/25 (12)	-	-	3/21 (14.3)	3/4 (75)	2/4 (50)
Ampicillin	58/105 (55.2)	4/12 (33.3)	2/5 (40)	17/25 (68)	-	-	6/21 (28.6)	3/4 (75)	2/4 (50)
Apramycin	3/100 (3)	0/11 (0)	0/2 (0)	2/25 (8)	-	-	0/20 (0)	0/4 (0)	0/4 (0)
Cefotaxime	3/89 (3.4)	0/3 (0)	-	-	-	-	0	0	0
Ceftazidime	2/89 (2.2)	0/3 (0)	-	-	-	-	0	0	0
Chloramphenicol	26/89 (29.2)	0/3 (0)	-	-	-	-	0/1 (0)	0	0
Enrofloxacin	1/105 (1)	0/12 (0)	0/5 (0)	4/25 (16)	-	-	0/21 (0)	0/4 (0)	0/4 (0)
Florfenicol	11/93 (11.8)	0/4 (0)	0/2 (0)	4/25 (16)	-	-	0/21 (0)	1/4 (25)	0/4 (0)
Neomycin	7/100 (7)	1/11 (9.1)	0/3 (0)	25/25 (100)	-	-	2/21 (9.5)	1/4 (25)	1/4 (25)
Spectinomycin	45/100 (45)	3/11 (27.3)	1/2 (50)	-	-	-	5/20 (25)	2/4 (50)	0/4 (0)
Streptomycin	38/89 (42.7)	1/3 (33.3)	1/1 (100)	-	-	-	0	0	0
Tetracycline	71/105 (67.6)	8/12 (66.7)	3/5 (60)	19/25 (76)	-	-	12/21 (57.1)	4/4 (100)	2/4 (50)
Trimetho/Sulph	24/105 (22.9)	1/12 (8.3)	1/5 (20)	10/25 (40)	-	-	5/21 (23.8)	1/4 (25)	1/4 (25)

Table A16.15 – Resistance in *E. coli* from sheep in England & Wales, Northern Ireland and Scotland in 2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**Neonatal**	**Pre-weaning**	**Adult**	**Neonatal**	**Post--weaning**	**Adult**	**Neonatal**	**Pre--weaning**	**Adult**
Amoxi/Clav	19/93 (20.4)	0/13 (0)	1/15 (6.7)	3/9 (33)	-	-	9/37 (24.3)	1/4 (25)	1/7 (14.3)
Ampicillin	60/93 (64.5)	8/13 (61.5)	4/15 (26.7)	7/9 (78)	-	-	17/37 (45.9)	1/4 (25)	1/7 (14.3)
Apramycin	0/93 (0)	1/12 (8.3)	0/6 (0)	0/9 (0)	-	-	1/35 (2.9)	0/4 (0)	0/7 (0)
Cefotaxime	2/74 (2.7)	0/6 (0)	0/1 (0)	-	-	-	0	0	0
Ceftazidime	1/74 (1.4)	0/6 (0)	0/1 (0)	-	-	-	0	0	0
Chloramphenicol	14/74 (18.9)	1/6 (16.7)	1/1 (100)	-	-	-	0/1 (0)	0	0
Enrofloxacin	2/93 (2.2)	0/13 (0)	0/15 (0)	0/9 (0)	-	-	2/37 (5.4)	0/4 (0)	0/7 (0)
Florfenicol	10/74 (13.5)	0/7 (0)	1/8 (12.5)	2/9 (22)	-	-	4/33 (12.1)	1/4 (25)	0/7 (0)
Neomycin	20/93 (21.5)	1/12 (8.3)	0/8 (0)	9/9 (100)	-	-	2/37 (5.4)	1/4 (25)	1/7 (14.3)
Spectinomycin	58/93 (62.4)	5/12 (41.7)	2/6 (33.3)	-	-	-	12/35 (34.3)	0/4 (0)	1/7 (14.3)
Streptomycin	51/74 (68.9)	3/6 (50)	1/3 (33.3)	-	-	-	1/1 (100)	0	0
Tetracycline	69/93 (74.2)	8/13 (61.5)	5/15 (33.3)	5/9 (56)	-	-	21/37 (56.8)	1/4 (25)	4/7 (57.1)
Trimetho/Sulph	32/93 (34.4)	2/13 (15.4)	1/15 (6.7)	4/9 (44)	-	-	6/37 (16.2)	1/4 (25)	0/7 (0)

Annex 17: Clinical surveillance data for *Salmonella* spp.

Table A17.1: Resistance in all *Salmonella* from cattle, pigs, sheep, chickens and turkeys (combined) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	297.9/1879 (15.9)	261/1358 (19.2)	281/1594 (17.6)	34/253 (13.4)	29/257 (11.3)	16/218 (7.3)	29/170 (17.1)	45/147 (30.6)	61/167 (36.5)
Amoxi/Clav	10/1879 (0.5)	0/1358 (0)	1/1594 (0.1)	11/253 (4.3)	6/257 (2.3)	3/218 (1.4)	7/170 (4.1)	15/147 (10.2)	17/167 (10.2)
Apramycin	34/1879 (1.8)	30/1358 (2.2)	59/1594 (3.7)	3/253 (1.2)	3/257 (1.2)	2/218 (0.9)	0/168 (0)	9/146 (6.2)	10/164 (6.1)
Cefotaxime	1/1879 (0.1)	0/1358 (0)	1/1594 (0.1)	0/253 (0)	0/257 (0)	0/218 (0)	0	0	0
Ceftazidime	1/1879 (0.1)	0/1358 (0)	1/1594 (0.1)	0/253 (0)	0/257 (0)	0/218 (0)	0	0	0
Ciprofloxacin	29/1879 (1.5)	19/1358 (1.4)	20/1594 (1.3)	0/253 (0)	0/257 (0)	0/218 (0)	0	0	0
Chloramphenicol	89/1879 (4.7)	107/1358 (7.9)	95/1594 (6)	20/253 (7.9)	10/257 (3.9)	6/218 (2.8)	1/1 (100)	0	0
Gentamicin	48/1879 (2.6)	34/1358 (2.5)	67/1594 (4.2)	2/253 (0.8)	3/257 (1.2)	2/218 (0.9)	0/1 (0)	0	0
Furazolidone	26/1879 (1.4)	10/1358 (0.7)	11/1594 (0.7)	1/253 (0.4)	0/257 (0)	0/218 (0)	0	0	0
Nalidixic Acid	127/1879 (6.8)	58/1358 (4.3)	98/1594 (6.1)	9/253 (3.6)	6/257 (2.3)	12/218 (5.5)	8/165 (4.8)	4/144 (2.8)	4/164 (2.4)
Neomycin	31/1879 (1.6)	18/1358 (1.3)	54/1594 (3.4)	-	-	-	0/170 (0)	1/147 (0.7)	1/167 (0.6)
Streptomycin	424/1879 (22.6)	351/1358 (25.8)	475/1594 (29.8)	45/253 (17.8)	57/257 (22.2)	37/218 (17)	0	0	0
Sulph Compounds	511/1879 (27.2)	379/1358 (27.9)	525/1594 (32.9)	38/253 (15)	28/257 (10.9)	25/218 (11.5)	0	0	0
Tetracycline	490/1879 (26.1)	350/1358 (25.8)	474/1594 (29.7)	38/253 (15)	26/257 (10.1)	17/218 (7.8)	38/168 (22.6)	65/147 (44.2)	77/167 (46.1)
Trim/Sulpho	222/1879 (11.8)	162/1358 (11.9)	199/1594 (12.5)	-	-	-	6/170 (3.5)	26/147 (17.7)	26/167 (15.6)

Table A17.2: Resistance in all *Salmonella* from cattle (all ages) from surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	25.9/518 (5)	32/427 (7.5)	23/346 (6.6)	16/153 (10.5)	3/115 (2.6)	2/81 (2.5)	10/105 (9.5)	3/59 (5.1)	12/73 (16.4)
Amoxi/Clav	0/518 (0)	0/427 (0)	0/346 (0)	3/153 (2)	1/115 (0.9)	1/81 (1.2)	4/105 (3.8)	3/59 (5.1)	11/73 (15.1)
Apramycin	0/518 (0)	0/427 (0)	0/346 (0)	1/153 (0.7)	0/115 (0)	0/81 (0)	0/105 (0)	0/59 (0)	0/73 (0)
Cefotaxime	0/518 (0)	0/427 (0)	0/346 (0)	0/153 (0)	0/115 (0)	0/81 (0)	0	0	0
Ceftazidime	0/518 (0)	0/427 (0)	0/346 (0)	0/153 (0)	0/115 (0)	0/81 (0)	0	0	0
Ciprofloxacin	0/518 (0)	0/427 (0)	1/346 (0.3)	0/153 (0)	0/115 (0)	0/81 (0)	0	0	0
Chloramphenicol	5/518 (1)	12/427 (2.8)	10/346 (2.9)	8/153 (5.2)	1/115 (0.9)	0/81 (0)	1/1 (100)	0	0
Gentamicin	1/518 (0.2)	0/427 (0)	0/346 (0)	0/153 (0)	0/115 (0)	0/81 (0)	0/1 (0)	0	0
Furazolidone	0/518 (0)	2/427 (0.5)	0/346 (0)	1/153 (0.7)	0/115 (0)	0/81 (0)	0	0	0
Nalidixic Acid	7/518 (1.4)	0/427 (0)	6/346 (1.7)	4/153 (2.6)	2/115 (1.7)	4/81 (4.9)	7/103 (6.8)	1/59 (1.7)	4/73 (5.5)
Neomycin	1/518 (0.2)	1/427 (0.2)	7/346 (2)	-	-	-	0/105 (0)	0/59 (0)	0/73 (0)
Streptomycin	32/518 (6.2)	35/427 (8.2)	20/346 (5.8)	23/153 (15)	15/115 (13)	8/81 (9.9)	0	0	0
Sulph Compounds	28/518 (5.4)	33/427 (7.7)	18/346 (5.2)	16/153 (10.5)	3/115 (2.6)	2/81 (2.5)	0	0	0
Tetracycline	32/518 (6.2)	35/427 (8.2)	21/346 (6.1)	16/153 (10.5)	3/115 (2.6)	2/81 (2.5)	12/105 (11.4)	9/59 (15.3)	13/73 (17.8)
Trim/Sulpho	4/518 (0.8)	9/427 (2.1)	0/346 (0)	-	-	-	0/105 (0)	0/59 (0)	12/73 (0)

Table A17.3: Resistance in all *Salmonella* from pigs (all ages) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	132/178 (74.2)	139/204 (68.1)	146/172 (84.9)	12/15 (80)	11/11 (100)	9/14 (64.3)	0	3/3 (100)	6/10 (60)
Amoxi/Clav	10/178 (5.6)	0/204 (0)	1/172 (0.6)	4/15 (26.7)	1/11 (9.1)	2/14 (14.3)	0	0/3 (0)	0/10 (0)
Apramycin	14/178 (7.9)	18/204 (8.8)	44/172 (25.6)	2/15 (13.3)	1/11 (9.1)	2/14 (14.3)	0	0/3 (0)	2/10 (10)
Cefotaxime	1/178 (0.6)	0/204 (0)	1/172 (0.6)	0/15 (0)	0/11 (0)	0/14 (0)	0	0	0
Ceftazidime	1/178 (0.6)	0/204 (0)	1/172 (0.6)	0/15 (0)	0/11 (0)	0/14 (0)	0	0	0
Ciprofloxacin	0/178 (0)	0/204 (0)	0/172 (0)	0/15 (0)	0/11 (0)	0/14 (0)	0	0	0
Chloramphenicol	50/178 (28.1)	75/204 (36.8)	73/172 (42.4)	4/15 (26.7)	4/11 (36.4)	5/14 (35.7)	0	0	0
Gentamicin	15/178 (8.4)	18/204 (8.8)	48/172 (27.9)	1/15 (6.7)	1/11 (9.1)	2/14 (14.3)	0	0	0
Furazolidone	0/178 (0)	1/204 (0.5)	0/172 (0)	0/15 (0)	0/11 (0)	0/14 (0)	0	0	0
Nalidixic Acid	3/178 (1.7)	2/204 (1)	1/172 (0.6)	1/15 (6.7)	1/11 (9.1)	2/14 (14.3)	0	0/3 (0)	0/10 (0)
Neomycin	5/178 (2.8)	8/204 (3.9)	12/172 (7)	-	-	-	0	0/3 (0)	1/10 (10)
Streptomycin	133/178 (74.7)	140/204 (68.6)	155/172 (90.1)	11/15 (73.3)	11/11 (100)	11/14 (78.6)	0	0	0
Sulph Compounds	150/178 (84.3)	152/204 (74.5)	156/172 (90.7)	11/15 (73.3)	11/11 (100)	11/14 (78.6)	0	0	0
Tetracycline	141/178 (79.2)	152/204 (74.5)	142/172 (82.6)	11/15 (73.3)	11/11 (100)	10/14 (71.4)	0	3/3 (100)	10/10 (100)
Trim/Sulpho	99/178 (55.6)	94/204 (46.1)	83/172 (48.3)	-	-	-	0	1/3 (33.3)	1/10 (10)

Table A17.4: Resistance in all *Salmonella* from sheep (all ages) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	2/91 (2.2)	0/59 (0)	4/57 (7)	1/26 (3.8)	0/12 (0)	0/17 (0)	0/34 (0)	3/26 (11.5)	1/24 (4.2)
Amoxi/Clav	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0/34 (0)	3/26 (11.5)	0/24 (0)
Apramycin	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0/32 (0)	1/25 (4)	0/22 (0)
Cefotaxime	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0	0	0
Ceftazidime	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0	0	0
Ciprofloxacin	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0	0	0
Chloramphenicol	0/91 (0)	0/59 (0)	0/57 (0)	1/26 (3.8)	0/12 (0)	0/17 (0)	0	0	0
Gentamicin	1/91 (1.1)	1/59 (1.7)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0	0	0
Furazolidone	0/91 (0)	0/59 (0)	0/57 (0)	0/26 (0)	0/12 (0)	0/17 (0)	0	0	0
Nalidixic Acid	0/91 (0)	0/59 (0)	0/57 (0)	1/26 (3.8)	0/12 (0)	1/17 (5.9)	1/32 (3.1)	1/25 (4)	0/22 (0)
Neomycin	0/91 (0)	0/59 (0)	0/57 (0)	-	-	-	0/34 (0)	0/26 (0)	0/24 (0)
Streptomycin	2/91 (2.2)	1/59 (1.7)	5/57 (8.8)	1/26 (3.8)	0/12 (0)	2/17 (11.8)	0	0	0
Sulph Compounds	2/91 (2.2)	1/59 (1.7)	4/57 (7)	1/26 (3.8)	0/12 (0)	2/17 (11.8)	0	0	0
Tetracycline	2/91 (2.2)	1/59 (1.7)	4/57 (7)	0/26 (0)	0/12 (0)	1/17 (5.9)	4/34 (11.8)	4/26 (15.4)	3/24 (12.5)
Trim/Sulpho	0/91 (0)	0/59 (0)	1/57 (1.8)	-	-	-	0/34 (0)	0/26 (0)	0/24 (0)

Table A17.5: Resistance in all *Salmonella* from chickens (all ages) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	63/850 (7.4)	32/525 (6.1)	73/768 (9.5)	16/48 (33.3)	14/106 (13.2)	5/104 (4.8)	0/1 (0)	0/1 (0)	0
Amoxi/Clav	0/850 (0)	0/525 (0)	0/768 (0)	3/48 (6.3)	4/106 (3.8)	0/104 (0)	0/1 (0)	0/1 (0)	0
Apramycin	20/850 (2.4)	12/525 (2.3)	14/768 (1.8)	1/48 (2.1)	2/106 (1.9)	0/104 (0)	0/1 (0)	0/1 (0)	0
Cefotaxime	0/850 (0)	0/525 (0)	0/768 (0)	0/48 (0)	0/106 (0)	0/104 (0)	0	0	0
Ceftazidime	0/850 (0)	0/525 (0)	0/768 (0)	0/48 (0)	0/106 (0)	0/104 (0)	0	0	0
Ciprofloxacin	12/850 (1.4)	3/525 (0.6)	5/768 (0.7)	0/48 (0)	0/106 (0)	0/104 (0)	0	0	0
Chloramphenicol	33/850 (3.9)	19/525 (3.6)	8/768 (1)	8/48 (16.7)	5/106 (4.7)	1/104 (1)	0	0	0
Gentamicin	30/850 (3.5)	15/525 (2.9)	18/768 (2.3)	0/48 (0)	2/106 (1.9)	0/104 (0)	0	0	0
Furazolidone	24/850 (2.8)	7/525 (1.3)	11/768 (1.4)	1/48 (2.1)	0/106 (0)	0/104 (0)	0	0	0
Nalidixic Acid	68/850 (8)	30/525 (5.7)	51/768 (6.6)	4/48 (8.3)	3/106 (2.8)	5/104 (4.8)	0	0	0
Neomycin	24/850 (2.8)	9/525 (1.7)	28/768 (3.6)	-/- (-)	-/- (-)	-/- (-)	0/1 (0)	0/1 (0)	0
Streptomycin	93/850 (10.9)	82/525 (15.6)	117/768 (15.2)	23/48 (47.9)	31/106 (29.2)	16/104 (15.4)	0	0	0
Sulph Compounds	185/850 (21.8)	101/525 (19.2)	158/768 (20.6)	16/48 (33.3)	14/106 (13.2)	10/104 (9.6)	0	0	0
Tetracycline	178/850 (20.9)	76/525 (14.5)	123/768 (16)	16/48 (33.3)	11/106 (10.4)	4/104 (3.8)	0/1 (0)	0/1 (0)	0
Trim/Sulpho	93/850 (10.9)	49/525 (9.3)	100/768 (13)	-/- (-)	-/- (-)	-/- (-)	0/1 (0)	0/1 (0)	0

Table A17.6: Resistance in all *Salmonella* from turkeys (all ages) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	75/242 (31)	58/143 (40.6)	35/251 (13.9)	-	-	-	0/7 (0)	1/6 (16.7)	0/1 (0)
Amoxi/Clav	0/242 (0)	0/143 (0)	0/251 (0)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Apramycin	0/242 (0)	0/143 (0)	1/251 (0.4)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Cefotaxime	0/242 (0)	0/143 (0)	0/251 (0)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Ceftazidime	0/242 (0)	0/143 (0)	0/251 (0)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Ciprofloxacin	17/242 (7)	16/143 (11.2)	14/251 (5.6)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Chloramphenicol	1/242 (0.4)	1/143 (0.7)	4/251 (1.6)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Gentamicin	1/242 (0.4)	0/143 (0)	1/251 (0.4)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Furazolidone	2/242 (0.8)	0/143 (0)	0/251 (0)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Nalidixic Acid	49/242 (20.2)	26/143 (18.2)	40/251 (15.9)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Neomycin	1/242 (0.4)	0/143 (0)	7/251 (2.8)	-	-	-	-	-	-
Streptomycin	164/242 (67.8)	93/143 (65)	178/251 (70.9)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Sulph Compounds	146/242 (60.3)	92/143 (64.3)	189/251 (75.3)	-	-	-	0/7 (0)	0/6 (0)	0/1 (0)
Tetracycline	137/242 (56.6)	86/143 (60.1)	184/251 (73.3)	-	-	-	0/7 (0)	1/6 (16.7)	0/1 (0)
Trim/Sulpho	26/242 (10.7)	10/143 (7)	15/251 (6)	-	-	-	-	-	-

Table A17.7: Resistance in all *Salmonella* Dublin from cattle, pigs, sheep, chickens and turkeys (combined) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	1/393 (0.3)	2/286 (0.7)	4/226 (1.8)	9/134 (6.7)	12/110 (10.9)	6/79 (7.6)	0	0	0
Chloramphenicol	0/393 (0)	0/286 (0)	1/226 (0.4)	0/134 (0)	0/110 (0)	0/79 (0)	1/1 (100)	0	0
Furazolidone	0/393 (0)	1/286 (0.3)	0/226 (0)	0/134 (0)	1/110 (0.9)	0/79 (0)	0	0	0
Nalidixic Acid	4/393 (1)	0/286 (0)	5/226 (2.2)	1/134 (0.7)	0/110 (0)	0/79 (0)	2/77 (2.6)	4/52 (7.7)	1/56 (1.8)
Neomycin	1/393 (0.3)	1/286 (0.3)	5/226 (2.2)	-	-	-	0/77 (0)	0/52 (0)	0/56 (0)
Streptomycin	5/393 (1.3)	7/286 (2.4)	9/226 (4)	0/134 (0)	0/110 (0)	0/79 (0)	0/77 (0)	0/52 (0)	0/56 (0)
Sulpha/Trim	0/393 (0)	2/286 (0.7)	0/226 (0)	1/134 (0.7)	0/110 (0)	0/79 (0)	0	0	0
Sulph Compounds	0/393 (0)	2/286 (0.7)	0/226 (0)	-	-	-	0/77 (0)	0/52 (0)	0/56 (0)
Tetracycline	0/393 (0)	1/286 (0.3)	1/226 (0.4)	2/134 (1.5)	2/110 (1.8)	5/79 (6.3)	1/75 (1.3)	0/52 (0)	0/56 (0)

Table A17.8: Resistance in all *Salmonella* Typhimurium from cattle, pigs, sheep, chickens and turkeys (combined) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	95/165 (57.6)	97/224 (43.3)	77/165 (46.7)	29/36 (80.6)	19/28 (67.9)	13/24 (54.2)	0	0	0
Chloramphenicol	3/165 (1.8)	2/224 (0.9)	0/165 (0)	20/36 (55.6)	10/28 (35.7)	6/24 (25)	0	0	0
Furazolidone	58/165 (35.2)	82/224 (36.6)	75.9/165 (46)	31/36 (86.1)	19/28 (67.9)	14/24 (58.3)	0	0	0
Nalidixic Acid	0/165 (0)	0/224 (0)	0/165 (0)	29/36 (80.6)	19/28 (67.9)	12/24 (50)	10/11 (90.9)	10/10 (100)	21/22 (95.5)
Neomycin	7.92/165 (4.8)	2/224 (0.9)	2/165 (1.2)	-	-	-	0/11 (0)	0/10 (0)	1/22 (4.5)
Streptomycin	1/165 (0.6)	0/224 (0)	4/165 (2.4)	31/36 (86.1)	10/28 (35.7)	13/24 (54.2)	10/11 (90.9)	9/10 (90)	17/22 (77.3)
Sulpha/Trim	90/165 (54.5)	89/224 (39.7)	85/165 (51.5)	0/36 (0)	0/28 (0)	0/24 (0)	0	0	0
Sulph Compounds	74/165 (44.8)	80/224 (35.7)	53/165 (32.1)	-	-	-	0/11 (0)	1/10 (10)	1/22 (4.5)
Tetracycline	100/165 (60.6)	98/224 (43.8)	80/165 (48.5)	4/36 (11.1)	1/28 (3.6)	2/24 (8.3)	4/11 (36.4)	1/10 (10)	4/22 (18.2)

Table A17.9: Resistance in all *Salmonella* other than Dublin and Typhimurium from cattle, pigs, sheep, chickens and turkeys (combined) from clinical surveillance in England and Wales, Northern Ireland and Scotland, 2013-2015

	No. resistant / No. tested (Percentage resistant)								
	England & Wales			Northern Ireland			Scotland		
Antibiotic	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Ampicillin	286/2328 (12.3)	233/1837 (12.7)	292/2198 (13.3)	29/36 (80.6)	19/28 (67.9)	13/24 (54.2)	0	0	0
Chloramphenicol	33/2328 (1.4)	29/1837 (1.6)	64/2198 (2.9)	20/36 (55.6)	10/28 (35.7)	6/24 (25)	0	0	0
Furazolidone	40/2328 (1.7)	33/1837 (1.8)	53/2198 (2.4)	31/36 (86.1)	19/28 (67.9)	14/24 (58.3)	0	0	0
Nalidixic Acid	72/2328 (3.1)	39/1837 (2.1)	42/2198 (1.9)	29/36 (80.6)	19/28 (67.9)	12/24 (50)	26/80 (32.5)	51/85 (60)	55/89 (61.8)
Neomycin	133/2328 (5.7)	73/1837 (4)	121/2198 (5.5)	-	-	-	0/82 (0)	1/85 (1.2)	0/89 (0)
Streptomycin	79/2328 (3.4)	37/1837 (2)	70/2198 (3.2)	31/36 (86.1)	10/28 (35.7)	13/24 (54.2)	19/82 (23.2)	36/85 (42.4)	44/89 (49.4)
Sulpha/Trim	447/2328 (19.2)	345/1837 (18.8)	497/2198 (22.6)	0/36 (0)	0/28 (0)	0/24 (0)	0	0	0
Sulph Compounds	284/2328 (12.2)	384/1837 (20.9)	229/2198 (10.4)	-	-	-	6/82 (7.3)	25/85 (29.4)	25/89 (28.1)
Tetracycline	617/2328 (26.5)	384/1837 (20.9)	580/2198 (26.4)	4/36 (11.1)	1/28 (3.6)	2/24 (8.3)	3/79 (3.8)	3/82 (3.7)	0/86 (0)

Table A17.10: Top ten *Salmonella* serovars isolated in Northern Ireland between 2013-2015

Rank	2013	2014	2015
1	Dublin / (458 isolations)	Dublin / (321 isolations)	Derby / (437 isolations)
2	Mbandaka / (278 isolations)	Mbandaka / (196 isolations)	Mbandaka / (335 isolations)
3	Montevideo / (248 isolations)	Kedougou / (128 isolations)	Dublin / (247 isolations)
4	Senftenberg / (205 isolations)	Senftenberg / (122 isolations)	Kedougou / (230 isolations)
5	Kedougou / (192 isolations)	Montevideo / (115 isolations)	13,23:i:- / (189 isolations)
6	Derby (176 isolations)	13,23:i:- / (107 isolations)	Senftenberg / (90 isolations)
7	13,23:i:- / (134 isolations)	Typhimurium / (105 isolations)	Enteritidis / (87 isolations)
8	Typhimurium / (87 isolations)	4,5,12:i:- / (71 isolations)	Typhimurium / (67 isolations)
9	Ohio / (65 isolations)	Derby / (54 isolations)	4,12:i:- / (58 isolations)
10	Newport / (59 isolations)	Newport / (44 isolations)	4,5,12:i:- / (54 isolations)

Table A17.11: Top ten *Salmonella* serovars isolated in Scotland between 2013-2015

Rank	2013	2014	2015
1	Dublin / (80 isolations)	Dublin / (58 isolations)	Dublin / (64 isolations)
2	Typhimurium / (34 isolations)	Typhimurium / (53 isolations)	Typhimurium / (49 isolations)
3	Arizonae / (23 isolations)	Arizonae / (16 isolations)	Arizonae / (17 isolations)
4	Montevideo / (18 isolations)	Montevideo / (8 isolations)	Montevideo / (9 isolations)
5	Bovismorbificans / (7 isolations)	Enteritidis / (4 isolations)	Spp. / (7 isolations)
6	Bovi / (6 isolations)	Spp. / (2 isolations)	Derby / (2 isolations)
7	Spp. / (4 isolations)	Mbandaka / (2 isolations)	Enteritidis / (2 isolations)
8	Derby / (2 isolations)	Bovismorbificans / (1 isolations)	Spp. / (6 isolations)
9	Tennessee / (2 isolations)	Group C2 / (1 isolations)	Mbandaka / (2 isolations)
10	Senfentenberg / (2 isolations)	Aarhus / (1 isolations	Senftenberg / (2 isolations)

Annex 18: Data limitations

Antibiotic sales data are considered to be an overestimate of use

- Sales data do 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.
- A given quantity of antibiotic may represent many doses in small animals or few doses in large animals. It is not possible to predict the number of doses represented by the quantity sold.
- Changes in quantities of veterinary antibiotics sold should be considered in parallel with changes in the UK animal population over the corresponding time period. The populations of animal species are an important denominator and may vary quite markedly from year to year depending on market conditions for livestock derived food. Similarly variations in the size of the animals being treated should be taken into consideration as larger animals will require a larger relative quantity of antibiotics over a treatment period.
- To try and address the variation in animal populations and demographics, over time and between countries, the ESVAC 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 is now used across EU member states and is currently the best approximation of consumption. We have used this form of analysis in this report.
- Sales data in general over estimate 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.
- Some products may be sold to UK feed mills for inclusion in feed which is then exported outside of the UK, currently there is no method for separating these sales from the total UK sales data, resulting in an over estimate of use in UK feed.
- 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. Further information on cascade prescribing can be found in Annex 5.

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. These factors are taken into consideration when the PCU is calculated (see Annex 2).

Resistance data, clinical surveillance

There are a number of limitations associated with the antibiotic resistance data and they should be borne in mind when interpreting results from the veterinary clinical surveillance. This is a biased population and cannot be considered to accurately reflect the bacterial populations present within the general animal population in the UK:

- Veterinary surgeons have the option to submit samples to private laboratories rather than Government laboratories/ Veterinary Investigation Centres. The proportion of samples that Government laboratories tests compared to other laboratories is not known, and therefore we cannot know how representative the samples processed by APHA, SACCVS, and AFBI are of total diagnostic submissions.

- Furthermore, geographical proximity of a farm or veterinary practice to a Government diagnostic laboratory may have an impact on the submission rate of samples; clinical surveillance may therefore, naturally, over-represent the animal populations within certain geographical areas.

- Other factors can also influence the submission rate of samples to veterinary diagnostic laboratories. These can include for example the severity of disease, impact on production or the value of the animals involved.

- The levels of resistance demonstrated by the clinical surveillance isolates presented in this report may be higher than those seen in the wider bacterial populations present within animals in England and Wales. This is because samples from diseased animals may be submitted from animals that have been unresponsive to initial antibiotic therapy, and thus the isolates recovered may have already been exposed to antibiotic pressure(s).

- Isolates from companion animals which are submitted to APHA are only investigated for antibiotic resistance if there is a public health concern, and therefore bacteria from these animal groups are under-represented in this report. APHA does not provide a veterinary diagnostic service for companion animals.

- The veterinary clinical surveillance data detail the number of bacterial isolates that underwent sensitivity testing, but not the numbers of animals for which samples were submitted for examination. Several bacteria may have been cultured from an individual animal or from a group of animals on the same farm. This type of clustering is not accounted for in the report, though since only low numbers of bacteria are usually subjected to susceptibility testing from the same outbreak of disease, its importance is probably limited.

- The diagnostic tests performed on any sample received through the clinical surveillance programme 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.

- The breakpoints used for determining resistance for isolates recovered under the veterinary clinical surveillance programme in GB are those as recommended by BSAC. These breakpoints 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 approximately 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 different animals and pharmacokinetics may vary between species. Currently, there is insufficient data available to apply animal species specific breakpoints to all organism/antibiotic combinations where these are required.

- Different antibiotic susceptibility testing methodologies are used in England & Wales (APHA), Scotland (SACCVS), and Northern Ireland (AFBI). APHA and SACCVS use BSAC methodology to determine resistance/susceptibility based on human clinical breakpoints, whilst AFBI use CLSI. **In light of the different methodologies and breakpoints used, the amalgamated results of UK wide monitoring should be interpreted with caution.**

- For AST testing done by APHA, in the case of some veterinary drug/bug combinations a BSAC cut-off may not exist. In this case, APHA may have derived a tentative or suggested breakpoint or the historical veterinary breakpoint (zone size cut-off of resistant <=13mm) may have been used to define resistance. The breakpoints used are set out in Annex x.

- *Escherichia coli* isolates are not collected from routine samples from healthy livestock in Northern Ireland. Only clinical cases submitted for post-mortem investigation when colibacillosis, or similar diseases, will proceed to isolate pathogenic *E. coli*. AMR testing on *E. coli* isolates is mainly performed if samples are coming from <2-week old calves and animals with bovine mastitis.

- With regards to *E. coli,* each organisation in the United Kingdom sets their own criteria for testing AMR in *E. coli* from clinically sick animals and these criteria are not uniform. This is pertinent to highlight as the selection of isolates for susceptibility testing based on age or other criteria can influence the result obtained. Bacterial isolates recovered from young animals can often be more resistant than those from older animals and this relates to the fact that antimicrobials are in general more frequently administered to young animals than to older animals.

Annex 19: Data sources

Marketing Authorisation Holders (MAHs)
It is mandatory for Market Authorisation Holders of manufactured antibiotics to provide the Veterinary Medicines Directorate with total annual sales data for each antibiotic product sold within the UK. Data are collected, verified and analysed to calculate the total weight, in tonnes, of each active ingredient sold for each antibiotic. Antibiotic sales data are collected as a proxy for antibiotic use.

Periodic Safety Update Reports (PSURs)
Sales figures submitted by MAHs in PSURs for the purpose of Pharmacovigilance, were used to validate sales figures published in this report. Where a PSUR had been returned to the VMD Pharmacovigilance team in the 2015 calendar year reported sales were compared to those returned to the AMR team and any discrepancies were queried.

To calculate the Population Correction Unit, data are 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.

Annex 20: Glossary of Terms

a.i.	Active Ingredient; the part of an antibiotic medicine that acts against the bacterial infection.
AHDB	Animal Health and Development Board
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 antibacterials.
Antimicrobial	A general term for any compound with a direct action on micro-organisms used for treatment or prevention of infections. Antimicrobials include antibacterials (antibiotics), antivirals, antifungals and antiprotozoals.
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.
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.
BPC	British Poultry Council
CBP	Clinical Break Point
CHAWG	Cattle Health and Welfare Group
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.
HP-CIA	Highest Priority Critically Important Antibiotics
Defra	Department for Environment, Food and Rural Affairs

ECDC	European Centre for Disease Prevention and Control
ECV	Epidemiological cut-off value
EFSA	European Food Safety Authority
EMA	European Medicines Agency
Eurostat	Eurostat is the statistical office of the European Union.
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
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.
Injectable Product	A product which is administered to animals via injection.
Intramammary Product	A product which is administered into the udder.
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 antibiotic 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.
Metaphylaxis	The treatment of a group of animals where one or more individuals within the group has received a clinical diagnosis.
Non-Food Animals	Animals not reared for food. These are mainly companion animals including, dogs, cats, horses, small mammals, rabbits and birds.
OIE	World Organisation for Animal Health
PHWC	Pig Health and Welfare Council
Population Correction Unit	This is a technical unit of measurement which is used to represent the estimated weight at treatment of livestock and slaughtered

(PCU)	animals. 1 PCU = 1 kg of different categories of livestock and slaughtered animals.
Sulphonamide	A group of bacteriostatic compounds that interfere with folic acid synthesis of susceptible organisms. They all have similar antibiotic 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.
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 21: Contributors

Compiled by:

The Veterinary Medicines Directorate
Woodham Lane
New Haw
Surrey, KT15 3LS

Contributing Pharmaceutical Companies and Other Marketing Authorisation Holders

- Alfasan Nederland BV
- Animalcare Limited
- aniMedica GmbH
- Avimedical
- Bayer Plc
- Bimeda Chemicals Ltd
- Boehringer Ingelheim Ltd
- Ceva Animal Health Ltd
- Chanelle Animal Health Ltd
- Continental Farmaceutica SL.
- CP Pharma Handelsgesellschaft mbH
- Cross Vetpharm Group Ltd
- Dechra Ltd
- Divasa Farmavic S.A.
- Dopharma Research B.V.
- ECO Animal Health
- Ecuphar N.V.
- Eli Lilly & Company Ltd
- Emdoka bvba
- Eurovet Animal Health B.V.
- Fatro S.P.A.
- Forte Healthcare Ltd
- Forum Products Limited
- Franklin Pharmaceuticals Ltd
- Global Vet Health S.L
- Harkers Ltd
- Huvepharma N.V.
- I.C.F. Sri Industria Chimica Fine
- Industrial Veterinaria S.A.
- Intervet UK Ltd
- Kela N.V.
- Kernfarm B.V.
- Krka Dd
- Laboratorios Calier S.A.
- Laboratorios Hipra S.A.
- Laboratorios Karizoo S.A.
- Laboratorios Maymo S.A.
- Laboratorios SYVA S.A.U
- Laboratorios Velvian, S.L.
- Lavet Pharmaceuticals Ltd
- Le Vet B.V.
- Listow Limited
- Merial Animal Health Ltd
- Miklich Laboratorios S.L
- Nimrod Veterinary Products Ltd
- Norbrook Laboratories Ltd
- Novartis Animal Health UK Ltd
- Oropharma N.V.
- Pharmaq Ltd
- Phibro Animal Health SA
- Qalian Ltd
- Richter Pharma
- Sogeval S.A.
- SP Veterinaria, S.A.
- Triveritas Ltd
- Universal Farma S.L
- Univet Ltd
- Vétoquinol UK Ltd
- Vetpharma Animal Health S.L
- Virbac S.A
- VMD NV

Contributors of other statistics:

- Defra Statistics Branch Scottish Government
- Department of Agriculture and Rural Development, Northern Ireland
- Centre for Environment Fisheries and Aquaculture Science