ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Scottish One Health Antimicrobial Use and Antimicrobial Resistance in 2020

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Reference this document as: ARHAI Scotland. Scottish One Health Antimicrobial Use and Antimicrobial Resistance Report 2020. ARHAI Scotland, 2020 [Report]

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Introduction

The Coronavirus disease (COVID-19) pandemic, which emerged in Scotland in February 2020, has had an unprecedented impact across society. There have been significant changes in healthcare delivery in all settings in 2020 as a response to the challenges presented by the pandemic. Comparing antimicrobial use (AMU) and antimicrobial resistance (AMR) in 2020 with previous years is challenging. The impact of COVID-19 on epidemiology of antimicrobial use and resistance will have implications for interpretation of the trends for the years ahead.

The COVID-19 pandemic has illustrated the impact of a newly emergent infectious disease with limited initial treatment options. AMR is not a new issue. It arises when micro-organisms such as bacteria develop the ability to withstand antimicrobial treatments making infections harder to treat with resultant severe disease and potentially death.

In January 2019, the UK Government published a five-year national action plan ‘Tackling antimicrobial resistance 2019–2024’ as well as a vision for AMR in 20 years ‘Contained and controlled: The UK’s 20-year vision for antimicrobial resistance’. The five-year national action plan focuses on three key aims to tackle AMR: reducing the burden of infection, optimising the use of antimicrobials, and developing new diagnostics, therapies, vaccines and interventions. The Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) programme, part of ARHAI Scotland (Antimicrobial Resistance and Healthcare Associated Infection), continues to provide intelligence and evidence for action to inform the development of local and national interventions and initiatives to tackle AMR. A One Health approach to tackling AMR was adopted in Scotland in 2016 and acknowledges that the health of humans, animals and the environment are interconnected. Antimicrobial use and spread of infection in humans, animals and the environment contribute to the development of resistant infections. In line with this approach, this report includes information from 2020 on antimicrobial use and resistance in humans, animals and the environment.

This report has been produced during the COVID-19 pandemic which has had a profound impact on healthcare services and for citizens of all ages in Scotland and beyond. There have been and will continue to be the emergence of new models of care and changes in the way antimicrobials are used. Tackling AMR, which has been described as a slow burning pandemic, remains vitally important and sustained action to preserve antibiotics and reduce

drug resistant infections is crucial to secure the future delivery of healthcare through and beyond the COVID-19 pandemic.

Main Points

The ongoing COVID-19 pandemic has had a large impact on antibiotic use during 2020, which will affect the reported numbers. Further information can be found in the ARHAI Scotland Healthcare Associated Infections, 2020 Annual Report.

Antimicrobial use in humans

- Total antibiotic use in humans has decreased by 17.1% since 2016.
- Over 60% of all antibiotic use in Scotland was Access antibiotics (recommended first line narrow spectrum agents).
- The majority of antibiotic use in humans occurs in primary care.
- Antibiotic use in primary care has decreased by 20.9% since 2016.
- 22.3% of the Scottish population received at least one course of antibiotics prescribed in primary care.
- Antibiotic use in acute hospitals has increased by 2.3% since 2016.
- Use of Watch and Reserve (restricted) antibiotics in acute hospitals has decreased by 10.4% since 2016.

Antimicrobial use in animals

- 16.2% of companion animal consultations in 2020 resulted in an antibiotic being prescribed; 90.5% of these were not from the group of antibiotics considered to be high priority critically important in humans.
- Scotland's Healthy Animals website continues to offer guidance for vets and animal keepers on disease avoidance and antimicrobial stewardship.

Antimicrobial resistance in humans

- Gram-negative bacteria are a common cause of serious infections in both healthcare and community settings.
- Antimicrobial non-susceptibility in Gram-negative bacteria significantly contributes to the overall burden of AMR.
- In 2020, *Escherichia coli* was the most common cause of Gram-negative bacteraemia in Scotland with an incidence of 76.9 per 100,000 population.
- Since 2019 non-susceptibility in *Escherichia coli* bacteraemia (ECB) has remained stable.
- Non-susceptibility of *Klebsiella pneumoniae* blood isolates remained stable between 2019 and 2020 apart from an increase in cefotaxime/ceftriaxone and ceftazidime.
- Non-susceptibility in *Enterococcus faecium* blood isolates has remained stable between 2019 and 2020.
- 45.6% of *Enterococcus faecium* blood isolates were non-susceptible to vancomycin.
- Urinary tract infections (UTI) are commonly diagnosed in community, healthcare and hospital settings and antimicrobial non-susceptibility in urinary isolates significantly adds to the burden of AMR.
- *Escherichia coli* is the most frequently isolated bacteria from urine specimens. The incidence of *Escherichia coli* urinary isolates has decreased 16.9% between 2019 and 2020.
- Between 2019 and 2020, antimicrobial non-susceptibility of *Escherichia coli* urinary isolates to co-amoxiclav decreased whilst non-susceptibility to fosfomycin increased.
- In 2020, 59 carbapenemase-producing organisms (CPOs) were reported with a rate of 1.1 per 100,000 population.

Antimicrobial resistance in animals

- Monitoring AMR in animals is a vital component of understanding and mitigating risk of AMR across the entire ecosystem.
- Intelligence relating to AMR in animals will continue to be developed to inform the evidence base supporting a One Health approach to AMR.

Results and Commentary

COVID-19 has impacted healthcare delivery in both hospital and community settings. Priorities were adjusted to respond to the pandemic, leading to changes to delivery of services and to the patient population, including a new cohort of patients being treated for COVID-19. This will make comparisons with previous years difficult and, for this reason, results presented in this report must be interpreted in the context of the pandemic and with due caution.

For further information on how COVID-19 has impacted healthcare delivery please see the ARHAI Scotland Healthcare Associated Infection annual report.

Antimicrobial Use

Antibiotic use in humans

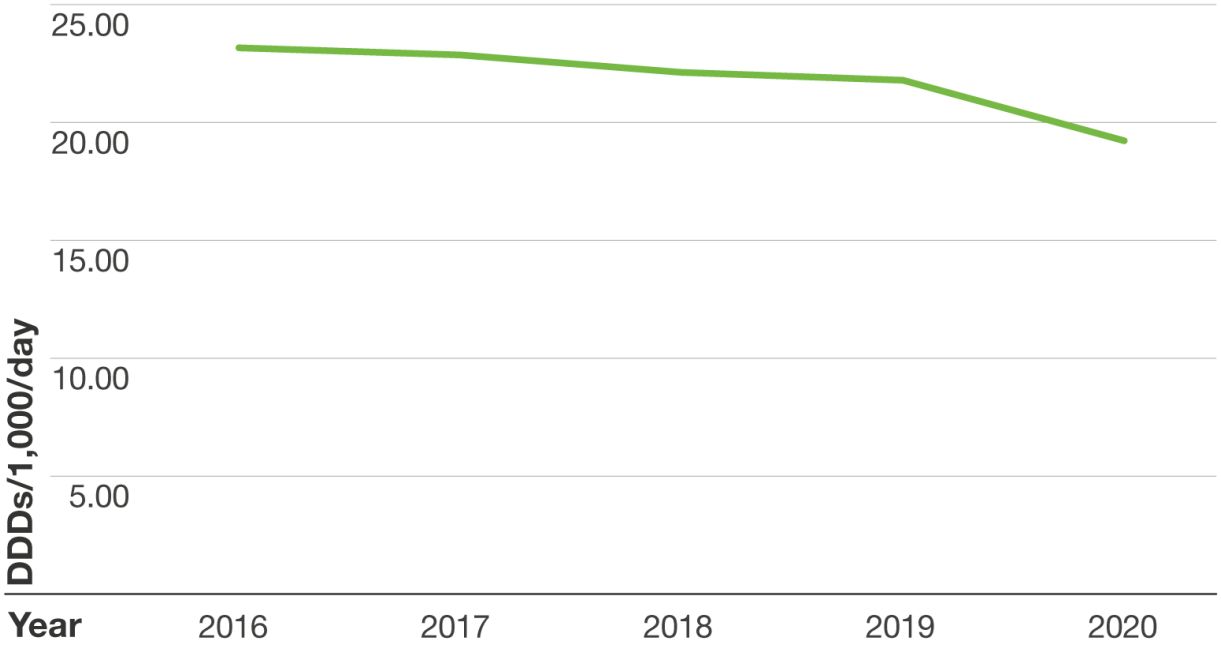
The UK's five-year National Action Plan (NAP) 2019 to 2024 to tackle AMR recognises that optimising antibiotic use in humans will slow the development of resistance and help to preserve the effectiveness of the currently available antibiotics. The NAP sets out measures of success to drive improvement and ambitious targets on antibiotic use. However, it is acknowledged that the threat from AMR will not be addressed in this single five-year action plan and further work will be required in line with the ambition of the UK 20-year vision for antimicrobial resistance.[1]

This chapter will describe the changes in antibiotic use in 2020 during the COVID-19 pandemic. This monitoring of the trends in antibiotic use undertaken by the SONAAR programme is crucial to the planning, prioritisation and evaluation of the impact of antimicrobial stewardship (AMS) interventions intended to optimise the use of antibiotics. In Scotland, the Scottish Antimicrobial Prescribing Group (SAPG) coordinates the national antimicrobial stewardship programme.

In 2020, the total use of antibiotics in humans across all settings was 19.2 defined daily doses (DDDs) per 1,000 population per day (DDDs/1,000/day). This is a year-on-year decrease of 4.0% ($p<0.001$) since 2016, with an overall reduction of 17.1% between 2016 and 2020

(**Figure 1**). The 11.8% reduction (p<0.001) between 2019 and 2020 is likely to be due to the impact of COVID-19 on antibiotic use in all settings.

Figure 1: Total number of defined daily doses per 1,000 population per day (DDDs/1,000/day) for all antibiotics prescribed in Scotland, 2016 to 2020, by year.

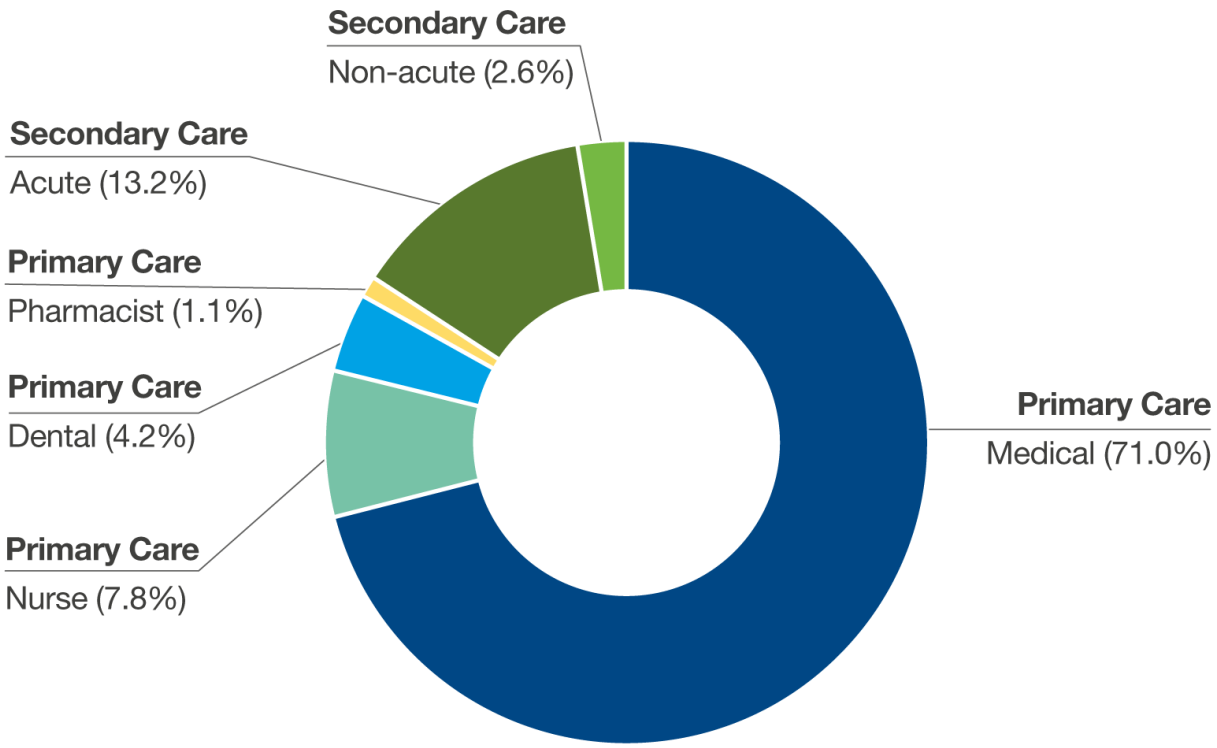


[Data Source: Prescribing Information System (PIS), Hospital Medicines Utilisation Database (HMUD) and National Records of Scotland (NRS)]

In 2020, 84.2% of antibiotic use (DDDs) occurred in primary care (community setting) with the remainder in secondary care (hospital setting). Antibiotic use in acute hospitals accounted for 13.2% of antibiotic use in humans (DDDs) with non-acute hospitals accounting for 2.6% (**Figure 2**). AMS is important in all settings to optimise antibiotic use.

The COVID-19 pandemic has led to innovations in healthcare delivery with new models of practice and evolving roles within multi-professional teams in Scotland. Accordingly, trends in the clinicians prescribing antibiotics continue to evolve. Currently within the national datasets the prescriber type can only be identified in primary care. In 2020, of the total use of antibiotics in humans (total DDDs), medical prescribers accounted for 71.0% of antibiotic use followed by nurses (7.8%), dentists (4.2%) and pharmacists (1.1%) (**Figure 2**).

Figure 2: Percentage of all antibiotics prescribed (DDDs) in Scotland by prescriber type, for 2020.



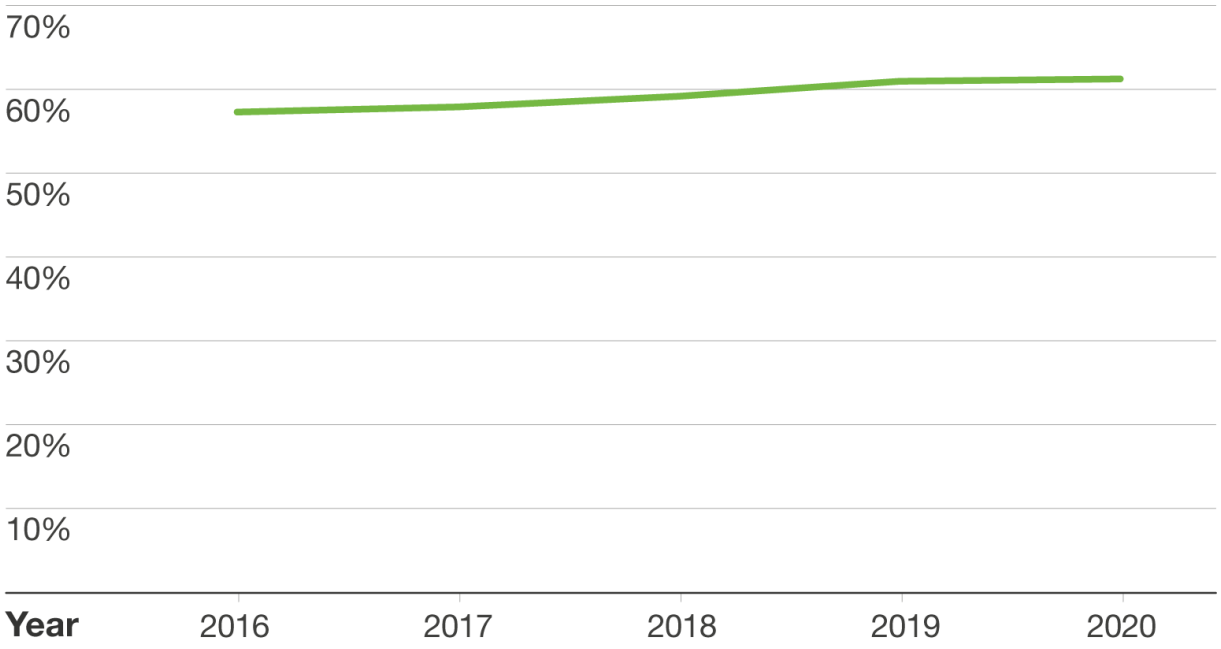
[Data Source: Prescribing Information System (PIS) and Hospital Medicines Utilisation Database (HMUD)]

The World Health Organization (WHO) has developed a classification system (adapted for use in the UK) which is used to monitor which antibiotics are being used. This system is known as AWaRe and splits antibiotics into three groups: Access are those that should be used as first line treatment for most common infections; Watch group antibiotics are not generally used first line but may be used in specific circumstances; and the Reserve group are those antibiotics that should be preserved for use when other treatment options are not appropriate as a result of known or suspected multi-drug resistance.

It is encouraging that Access antibiotic use in DDDs as a proportion all antibiotic DDDs in humans has been increasing year-on-year since 2016 (1.9%, $p<0.001$). In 2020, Access antibiotics accounted for 61.2% of total antibiotic use in humans (DDDs in all primary care and secondary care settings) (**Figure 3**). This is an increase since 2019 (0.5%, $p<0.001$) and indicates that during the COVID-19 pandemic clinicians across all sectors of care continued to

follow treatment choice recommendations within local antibiotic prescribing guidelines. These guidelines promote the use of narrow spectrum antibiotics over broad spectrum antibiotics where clinically appropriate. The inappropriate use of broad spectrum antibiotics is a modifiable prescribing factor which increases the risk of development of AMR. The COVID-19 pandemic did not increase the use of broader spectrum Watch and Reserve group antibiotics which suggests good antimicrobial stewardship has been maintained.

Figure 3: Percentage of all antibiotics prescribed (DDDs) in Scotland that belonged to the 'Access' group, 2016 to 2020, by year.



[Data Source: Prescribing Information System (PIS) and Hospital Medicines Utilisation Database (HMUD)]

Total Antibiotic Use in Humans Key Points

- **Antibiotic use in humans decreased by 17.1% since 2016.**
- **Antibiotic use in humans decreased by 11.8% between 2019 and 2020 which is likely to be due to the impact of COVID-19 on antibiotic use in all settings.**
- **The majority of antibiotic use occurs in primary care.**
- **The proportion of total antibiotic use which are WHO Access (first-line) antibiotics has remained above 60% during the COVID-19 pandemic.**

Antimicrobial use in primary care

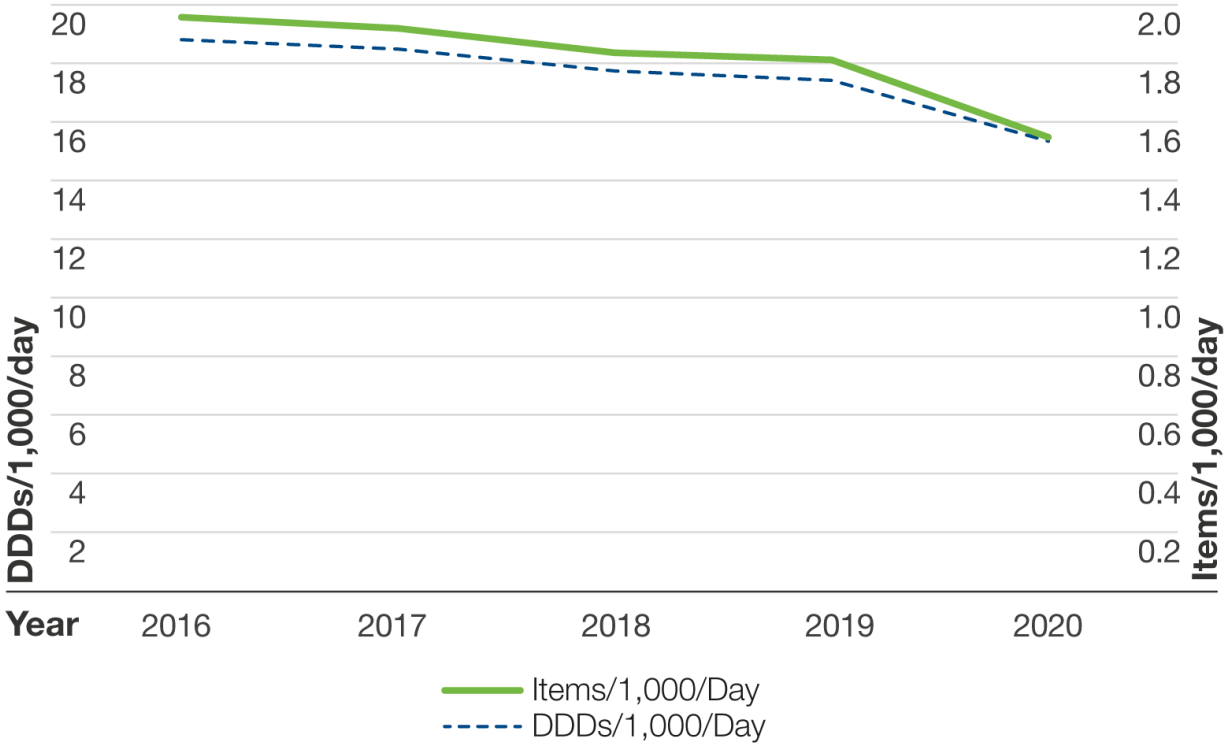
In 2020, 84.2% of all antibiotic use occurred in the primary care setting therefore optimising antibiotic use in primary care will contribute considerably to NAP ambition to reduce antibiotic use. There are three main approaches to optimising antibiotic use in primary care. Antibiotic use in otherwise healthy people for symptoms such as coughs, sore throats, colds and earache must be minimised. Where there is a clinical need to use antibiotics, it is important to avoid unnecessary exposure by using antibiotics for the recommended evidenced based duration specified within local guidelines and also to avoid use of broad spectrum antibiotics where possible.

The use of antibiotics in primary care (excluding dental prescribing) in 2020 was 1.55 items per 1,000 population per day. This is a year-on-year decrease of 5.0% ($p < 0.001$) since 2016, with an overall reduction of 20.9% between 2016 and 2020 (**Figure 4**). When expressed using DDDs, antibiotic use was 15.4 DDDs per 1,000 population per day; a year-on-year decrease of 4.5% ($p<0.001$) since 2016, with an overall reduction of 18.4% between 2016 and 2020. The proportion of the Scottish population that received at least one course of antibiotics (in primary care, excluding dental) was 22.3% in 2020 compared to 26.8 % in 2019.

Differences in healthcare provision and activity during the COVID-19 pandemic may have affected the percentage change in 2020 compared to previous years. During the COVID-19 pandemic it is likely that self-limiting respiratory tract infections were less frequent due to reduced transmission of infection during lockdown restrictions and/or that patients were more

likely to practice self-care leading to reduced use of antibiotics for these conditions. It is also possible that changes in public behaviour through improved hand hygiene, infection prevention and control practice and desire to protect the NHS may have contributed. An increased awareness of differences between viral and bacterial infections due to the intensive COVID-19 media coverage and increased use of the NHS Inform website for self-care advice are also likely to have played a part in reduced antibiotic use. It will be important for clinicians and the national stewardship programme to build on these changes in public behaviours to maximise opportunities for optimising antibiotic use as the NHS recovers from the COVID-19 pandemic.

Figure 4: Antibiotic prescribing in primary care (excluding dental prescribing) in Scotland, 2016 to 2020, by defined daily doses per 1,000 population per day (DDDs/1,000/Day) and items per 1,000 population per day (Items/1,000/Day), by year.



[Data Source: Prescribing Information System (PIS) and National Records of Scotland (NRS)]

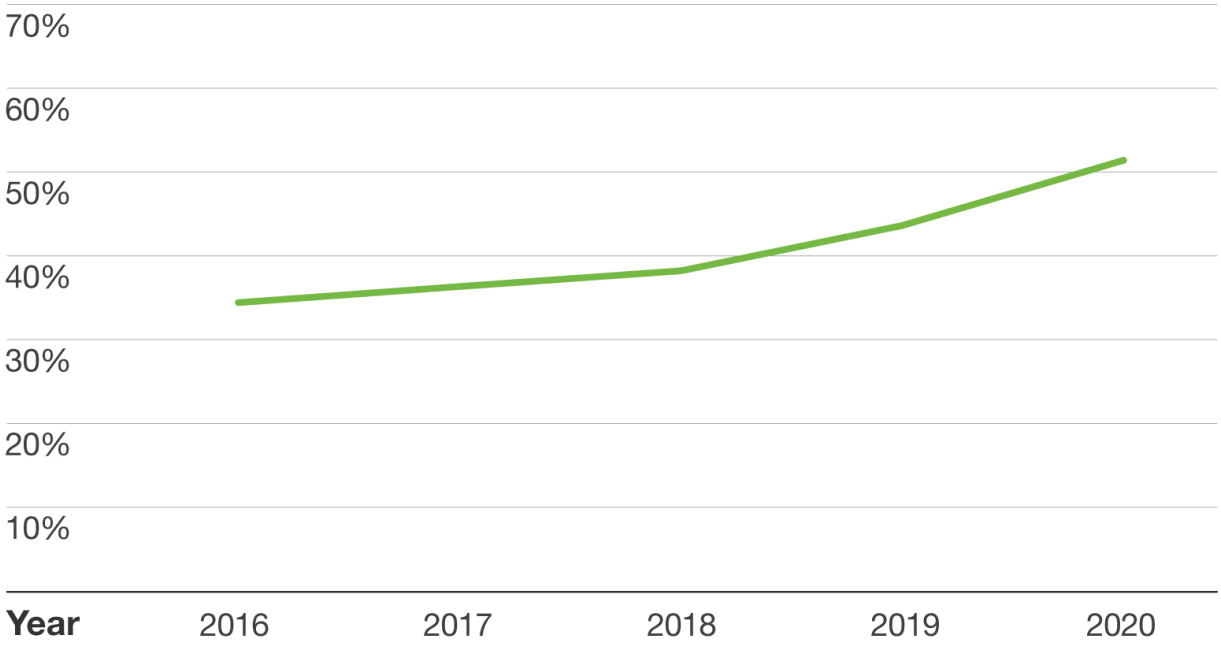
In 2020, 76.8% of antibiotic items dispensed in primary care (excluding dental prescribing) were from the WHO Access group, i.e. recommended first line narrow spectrum agents. This compares to 77.1% in 2019 and indicates that clinicians in primary care continued to follow

antibiotic prescribing guidelines throughout the COVID-19 pandemic in 2020. For more detail on use of particular antibiotics and antibiotic classes, see **Appendix.**

Treatment of respiratory infection is the most common reason for antibiotic use in primary care[2] and the evidence supports that where antibiotics are required (recognising antibiotics are not always needed), with a five-day course of amoxicillin is the recommended first line treatment.[3]

In 2020, 51.7% of all prescriptions for amoxicillin dispensed in primary care (excluding dental) were, on the basis of the quantity supplied, for five-day duration compared to 34.6% in 2016 (**Figure 5**). Between 2016 and 2020, there has been a year-on-year increase in the percentage of amoxicilin prescribed for five-day duration of 10.4% ($p<0.001$). For more detail on duration of other antibiotics, see **Appendix**. The SAPG has recognised that evidenced based recommendations in antibiotic prescribing guidelines for shorter courses of antibiotics is an important way to reduce individual and population exposure to unnecessary antibiotics. These data suggest that, even during the COVID-19 pandemic, clinicians in primary care are following guideline recommendations on treatment duration.

Figure 5: Proportion of amoxicillin 500mg capsule prescriptions with five-day course durations in general practice, 2016 - 2020, by year.



[Data Source: Prescribing Information System (PIS)]

The emergence of the COVID-19 pandemic in 2020 led to a change in the way the public engaged with NHS services through a greater use of telephone or video consultation and a continued evolution of professional roles for clinicians. General practitioners (GPs) remain responsible for the majority of antibiotic prescriptions. In 2020, GPs accounted for 71.0% of all antibiotic items compared to 76.9% in 2016.

In 2020, nurses accounted for 12.0% of all antibiotic items dispensed in the community, compared to 12.2% in 2019. Between 2016 and 2020, there has been a year-on-year increase in the items per 1,000 patients per day prescribed by nurses (10.6%, $p<0.001$), but since 2019, there has been a decrease (13.1%, $p<0.001$) (**Figure 6**). WHO Access antibiotics (items) accounted for 86.3% of nurse prescribing in 2020, compared to 2019 (86.7%) suggesting that nurses have continued to follow local guideline recommendations.

The trends in antibiotic use in primary care (excluding dentists) indicate that the COVID-19 pandemic has been associated with reduced antibiotic use, whereas in dentistry a different trend has emerged. After several years of successive reductions, in 2020 antibiotic use by dentists was 0.18 items per 1,000 patients per day compared to 0.14 items per 1,000 patients per day in 2019 (**Figure 7**). This is an increase of 27.9% between 2019 and 2020 ($p<0.001$).

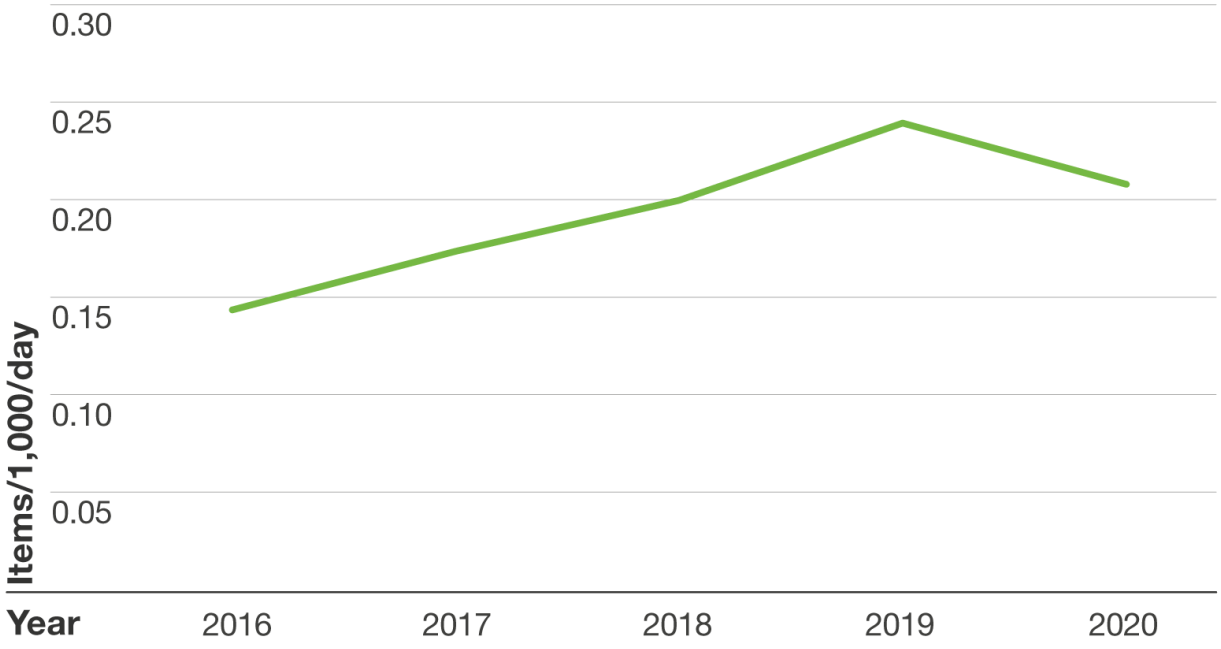
The COVID-19 pandemic led to a large change in service provision and patient activity within dentistry. During the lockdown phase of the pandemic dentists were unable to see patients for dental intervention treatment but were still able to prescribe antibiotics. The SAPG Dental Stewardship subgroup continues to coordinate work by stakeholders and support optimisation of dental antibiotic use as dental practices continue to remobilise and move toward normalisation of dental services.

Dentists can prescribe a limited range of antibiotics on NHS prescription in Scotland with two antibiotics, amoxicillin (67.1%) and metronidazole (28.9%) accounting for the majority of dental antibiotic use (items). In October 2020 the SAPG Dental Stewardship subgroup recommended that phenoxymethylpenicillin (penicillin V) was recommended first line when antibiotics are required for acute dento-alveolar infections.[4] This recommendation was made on the basis of narrower spectrum of antimicrobial activity than amoxicillin, but equivalent efficacy and clinical outcomes in acute dento-alveolar infections.[5] Limiting unintended consequences of antimicrobial use is a key principle of antimicrobial stewardship and since amoxicillin has a broader spectrum of activity than penicillin V, it has a greater impact on selection of resistance in the host micro-flora.[6] In 2020, penicillin V accounted for 1.6% of total antibiotic use by dentists compared to 0.4% in 2019.

The role of pharmacists, especially community pharmacists, as independent prescribers of antibiotics and via Patient Group Direction supply continues to evolve. This is a result of the continued development of NHS Pharmacy First Scotland service which enables people with common conditions to be reviewed by a community pharmacist to support self-care, provide timely antibiotic treatment or referral to other NHS services. In 2020, there were 96,537 antibiotic prescriptions written and dispensed by pharmacists in Scotland, representing 2.8% of total antibiotic use in primary care (items) compared to 0.2% in 2016. Of pharmacist antibiotic prescriptions, 67.9% were for trimethoprim, the recommended first line antibiotic for lower urinary tract infection in women in Pharmacy First.

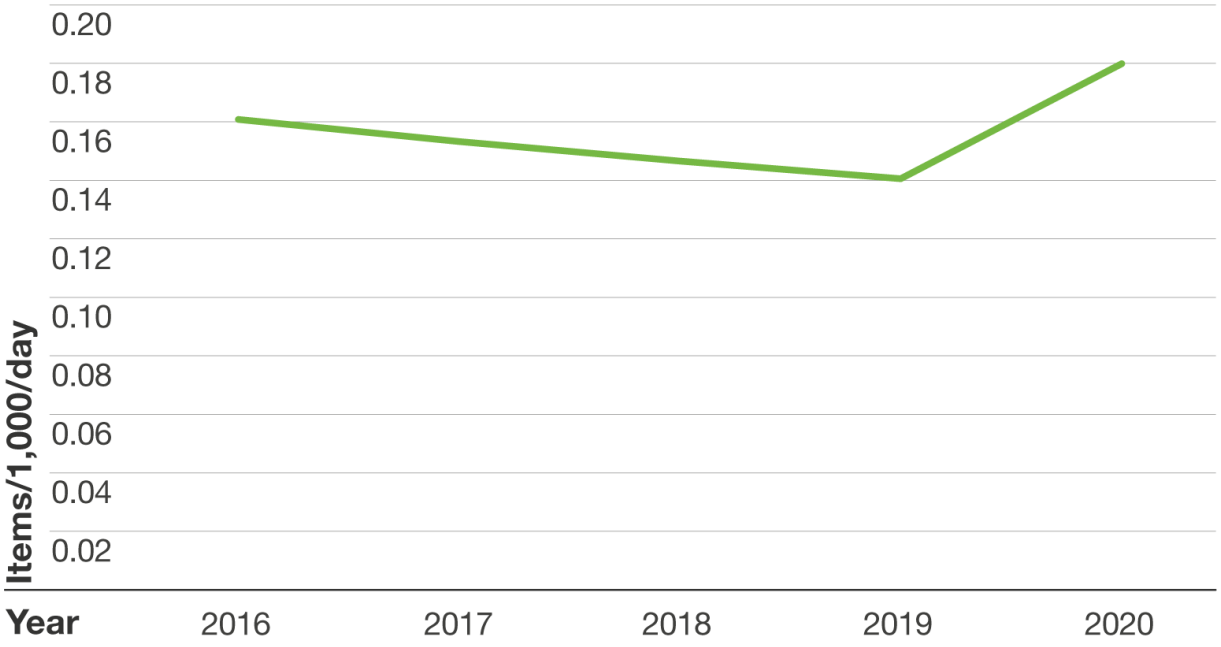
The multi-professional approach to antibiotic prescribing in primary care in Scotland reinforces the need to ensure all prescribers and clinicians irrespective of profession must be included in communications and education to optimise antibiotic use through local and national AMS initiatives.

Figure 6: Antibiotic prescribing by nurses in primary care in Scotland (items per 1,000 population per day; Items/1,000/Day), 2016 to 2020.



[Data Source: Prescribing Information System (PIS) and National Records of Scotland (NRS)]

Figure 7: Antibiotic prescribing by dentists in primary care in Scotland (items per 1,000 population per day; Items/1,000/Day), 2016 to 2020.



[Data Source: Prescribing Information System (PIS) and National Records of Scotland (NRS)]

Antibiotic Use in Primary Care Key Points

- **Over 80% of antibiotic use occurs in primary care.**
- **Antibiotic use in 2020 was at the lowest rate on record and 20.9% lower than in 2016.**
- **WHO Access (first line) antibiotics accounted for more than three quarters of all antibiotic use.**
- **Increase in proportion of amoxicillin 5 day courses since 2016.**
- **Increased use of antibiotics by dentists between 2019 and 2020.**
- **COVID-19 pandemic has had an impact on antibiotic use in 2020.**

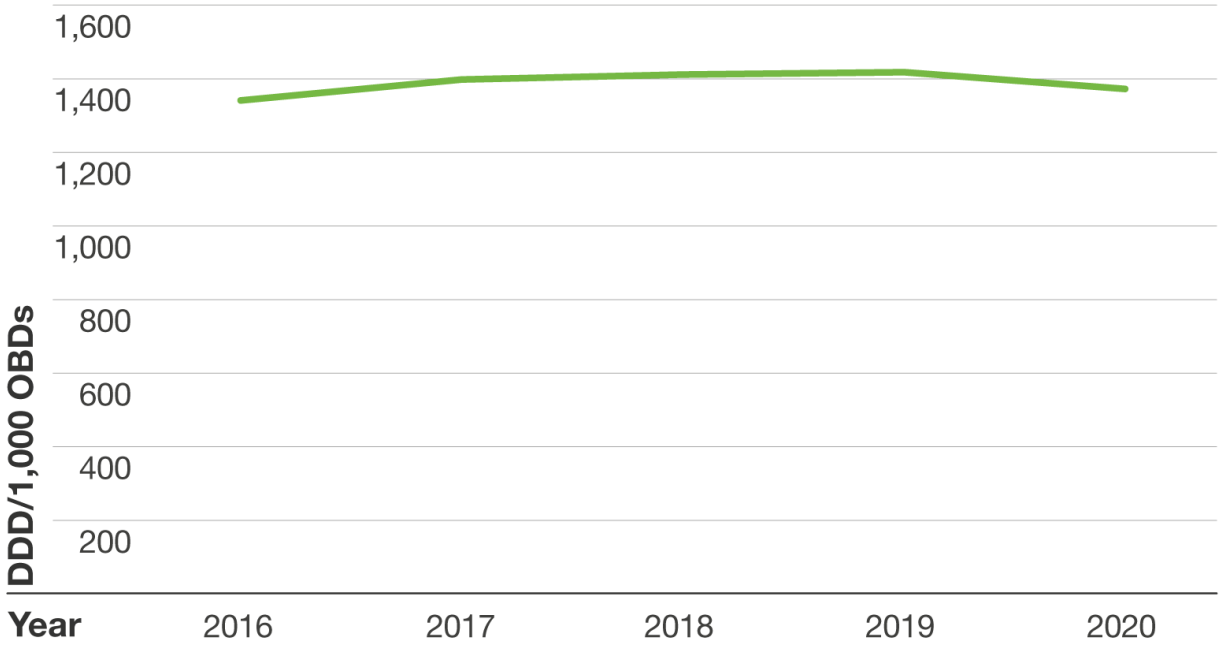
Antibiotic use in acute hospitals

Drug resistant infections continue to present a threat to patients in acute hospitals, many of whom will have other comorbidities and where infections can be more severe and complex. As such optimising antibiotic use through AMS is vitally important to preserve the effectiveness of antibiotics and optimise outcomes for patients.

During the COVID-19 pandemic in 2020 there have been marked changes in healthcare delivery, activity and changing patient populations with acute hospitals. In 2020, there were 25.1% fewer patients admitted to acute hospitals compared to 2019 and a decrease of 14.2% in total occupied bed days in 2020 compared to 2019.[7;8] Not only were there fewer people treated in hospitals in 2020, the case mix and reason for admission were very different: a higher proportion of people aged 65 and older was admitted to acute hospitals in 2020 compared to 2019 (42.6% in 2020 compared to 39.9% in 2019); there was a higher proportion of emergency admissions to acute hospitals in 2020 compared to 2019 (54.6% in 2020 compared to 47.5% in 2019); and there was a decrease of 37.5% in elective procedures within acute hospitals in 2020 compared to 2019 (80,000 in 2020 compared to 128,000 in 2019). These changes have influenced the trends in antibiotic use and limit comparison of 2020 with previous years.

In 2020, 13.2% of total antibiotic use (DDDs) in humans occurred in acute hospitals. There were 5,070,674 antibiotic defined daily doses used in 2020 compared to 6,226,332 in 2019, a reduction of over 1.1 million DDD. When expressed as rate using DDDs per 1,000 occupied bed days (OBD), antibiotic use was 1,372.5 DDD/1,000 OBD in 2020 compared to 1,418.0 DDD/1,000 OBD in 2019 (**Figure 8**). There has been an overall increase in the rate of antibiotic use (DDD/1,000 OBD) of 2.3% between 2016 and 2020 however, between 2019 and 2020, there was a 3.2% ($p<0.001$) reduction in the rate of antibiotic use in acute hospitals. This represents the first annual reduction since 2016 and is likely to be due to the impact of COVID-19 on antibiotic use in hospitals. As NHS services remobilise after the COVID-19 pandemic it will be important to optimise antibiotic use through AMS. The SONAAR programme will continue to support the SAPG through regular monitoring and reporting of trends in antibiotic use to identify areas for improvement.

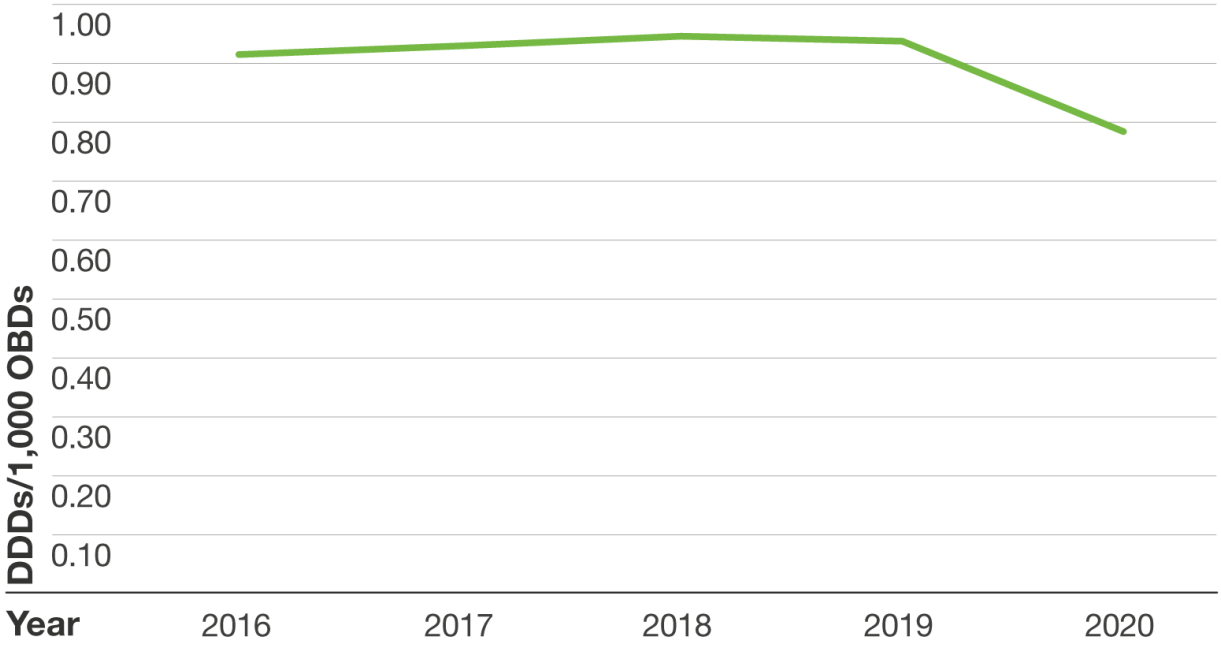
Figure 8: Antibiotic prescribing in acute hospitals in Scotland (defined daily doses per 1,000 occupied bed days; DDDs/1,000 OBDs), 2016 to 2020, by year.



[Data Source: Hospital Medicines Utilisation Database (HMUD) and Information Services Division (ISD(S)1)]

In 2019, a national indicator was developed to measure progress with achieving reliable and timely review of intravenous (IV) antibiotic therapy. This indicator and its associated target was that use of IV antibiotics in hospitals will be no higher in 2022 than it was in 2018. In 2020, antibiotics given intravenously accounted for 30.9% of total antibiotic use (DDDs) in acute hospitals. The rate of IV antibiotic use in all secondary care in 2020 was 0.80 DDDs per 1,000 population per day compared to 0.96 in 2019 (**Figure 9**). The reduced number of admissions and elective procedures during the COVID-19 pandemic will have impacted the DDDs in acute hospitals.

Figure 9: Acute and Non-Acute Hospital Use of Parenteral Antibiotics in Scotland, (defined daily doses per 1,000 occupied bed days; DDDs/1,000 OBDs), 2016 to 2020, by year.



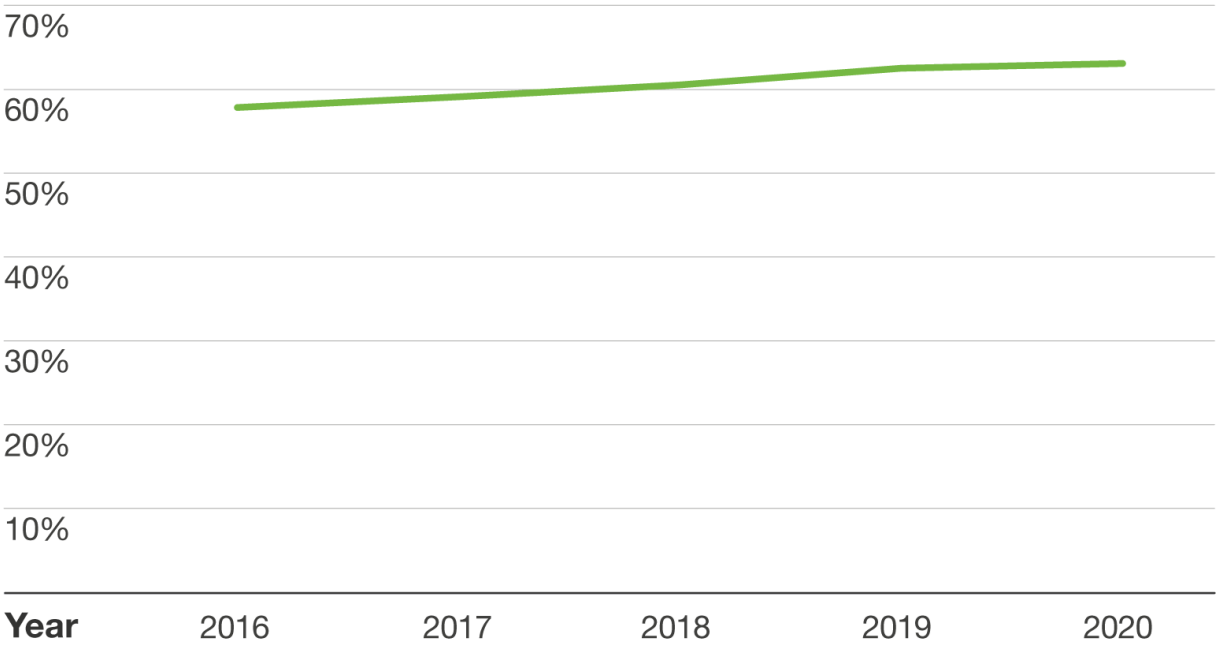
[Data Source: Hospital Medicines Utilisation Database (HMUD) and Information Services Division (ISD(S)1)]

The choice of initial empiric antibiotic treatment of infection in hospitalised patients remains an important component of hospital AMS and use of local antibiotic guidelines to inform this are embedded in clinical practice across NHS Scotland. These guidelines are evidenced based and promote the use of narrower spectrum antibiotics where clinically appropriate and restrict the use of broader spectrum treatments. During 2020, the SAPG produced advice on hospital

antibiotic management and antimicrobial stewardship in the context of the COVID-19 pandemic.[8] This included advice on when to initiate antibiotics in patients with suspected or proven COVID-19 infection and recommendations on empirical antibiotic choice and duration together with early diagnostic and de-escalation strategies to optimise antibiotic use and minimise antibiotic related harm.

In 2020, 63.1% of antibiotic use (DDDs) in acute hospitals was Access group antibiotics compared to 62.5% in 2019 (**Figure 10**). For more detail on use of particular antibiotics and antibiotic classes, see **Appendix**. A national indicator was launched in 2019 with a target that at least 60% of all antibiotic use in acute hospitals should be Access antibiotics. These most recent data suggest that hospital clinicians are following antibiotic guidelines, resulting in the Access target being achieved. Moreover, it indicates that in 2020, during the COVID-19 pandemic, there has been no move away from use of Access antibiotics for treatment or prophylaxis of infection in acute hospitals.

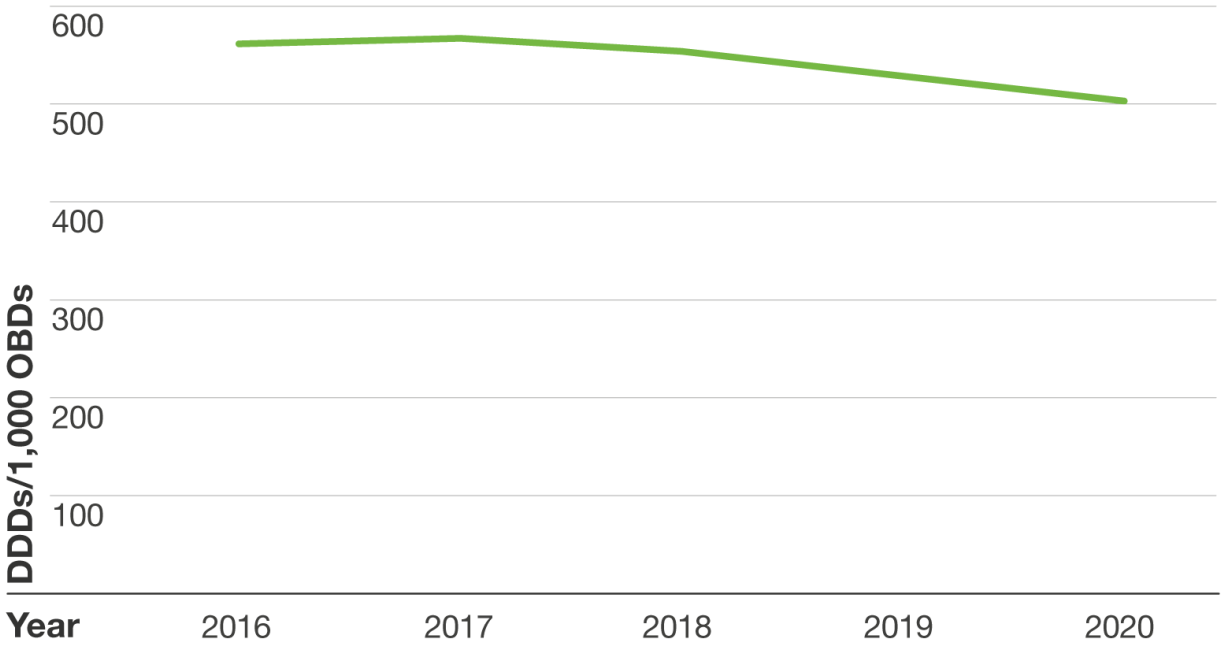
Figure 10: Percentage of all antibiotics prescribed (DDDs) in acute hospitals in Scotland that belonged to the 'Access' group, 2016 to 2020.



[Data Source: Hospital Medicines Utilisation Database (HMUD)]

In 2020, the rate of use of WHO Watch and Reserve antibiotics was 502.9 DDD/1,000 OBD, compared to 528.4 DDD/1,000 OBD in 2019 (**Figure 11**). This is a year-on-year decrease of 2.8% ($p<0.001$) since 2016, with an overall reduction of 10.4% between 2016 and 2020. As with the increasing proportion of Access antibiotics, this suggests that during the COVID-19 pandemic clinicians in acute hospitals have followed treatment choices recommended in local prescribing guidelines and have not increased the use of broader spectrum antibiotics. One of the ambitions in the UK AMR national action plan is a target to reduce by 10% the use of WHO Reserve and Watch categories of antibiotics in acute hospitals by 2024 (using 2017 as baseline). The data suggest that Scotland is on track to achieve this ambition.

Figure 11: 'Watch' and 'Reserve' group antibiotic prescribing in acute hospitals in Scotland (defined daily doses per 1,000 Occupied Bed Days; DDDs/1,000 OBDs), 2016 to 2020, by year.



[Data Source: Hospital Medicines Utilisation Database (HMUD) and Information Services Division (ISD(S)1)]

Antibiotic Use in Acute Hospitals Key Points

- **In 2020 there were 1.1 million fewer antibiotic defined daily doses compared to 2019.**
- **Change in antibiotic use in 2020 is likely to be due to the impact of COVID-19 pandemic.**
- **Over 60% of total antibiotic use in acute hospitals was WHO Access (first-line) antibiotics through the COVID-19 pandemic.**
- **A continued decreased use of WHO Watch and Reserve (restricted) antibiotics since 2016.**

Antibiotic use in animals

In the same way that optimisation of antimicrobial use in humans is required to tackle the risk of AMR, the optimisation of antimicrobial use in animals is also important. Historically, data on antimicrobial use in animals has comprised of sales data compiled at the UK level and published in the annual UK-Veterinary Antimicrobial Resistance and Sales Surveillance (VARSS) Report.[9] The publication of animal AMU data in the Responsible Use of Medicines in Agriculture Alliance (RUMA) Targets Task Force Report[10] and VARSS Report of 2020 demonstrate serious commitment to antimicrobial stewardship in the face of ongoing bacterial disease challenge in animal species as part of a One Health response to AMR in the UK.

Scottish animal AMU data were made available from veterinary practices in Scotland contributing to the Small Animal Veterinary Surveillance Network (SAVSNET), and provide an opportunity to further describe antimicrobial prescribing in the animal component of the One Health ecosystem. In order to: 1) optimise disease avoidance and prescribing in veterinary practice, 2) improve education, training and public engagement and 3) provide better access to and use of surveillance data in animal sectors, the Scotland's Healthy Animals website was developed. The website was created with stakeholders in the animal health sector and brings together expert advice on keeping animals healthy. Trusted guidance is signposted for all animal keepers and their vets, for countryside users, and for wildlife and rescue centres, and the website also hosts Scotland's Poultry Hub for poultry keepers, in particular smallholders.

Antimicrobial Use (AMU) Summary

A summary of the available data is provided in **Table 1**. In 2020, 13 small veterinary practices in Scotland contributed data from 37,794 individual consultations and 24,181 individual animals. For this analysis, high priority critically important antimicrobials (HP-CIA) are identified according to the categorisation by the Antimicrobial Advice Ad hoc Expert Group (AMEG) of the European Medicines Agency (EMA) and include fluoroquinolones, 3rd and 4th generation cephalosporins, and colistin.[11;12]

Table 1: Summary characteristics for all companion animals in Scottish veterinary practices, 2016 to 2020 inclusive.

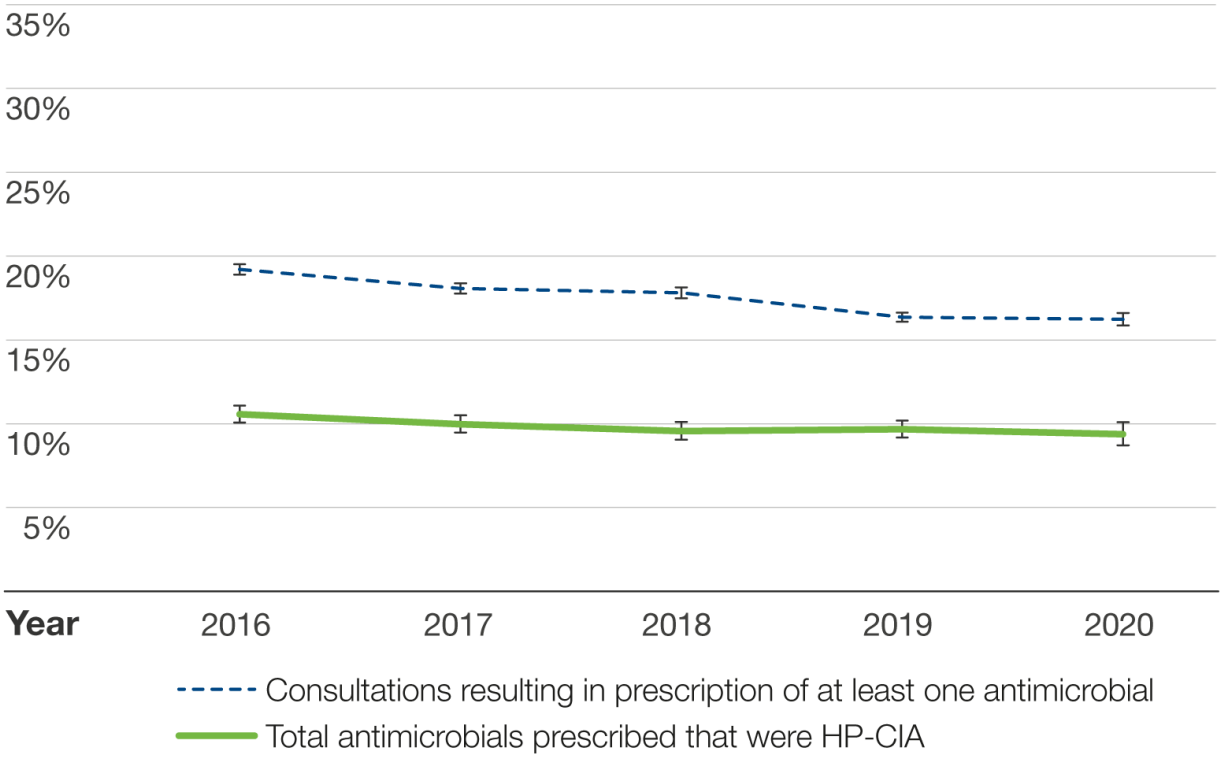
	2016	2017	2018	2019	2020
Number of contributing practices	11	11	15	15	13
Number of animals	26,646	26,138	30,145	36,933	24,181
Number of antimicrobials prescribed	14,640	12,885	11,832	13,132	6,888
Number of consultations	61,542	57,886	54,824	69,992	37,794
Number of consultations resulting in prescription of at least one antimicrobial	11,805	10,445	9,750	11,433	6,129
Percentage of consultations resulting in prescription of at least one antimicrobial	19.2%	18.0%	17.8%	16.3%	16.2%
Percentage of antimicrobials prescribed that were high priority critically important antimicrobials (HP-CIA)*	10.6%	10.0%	9.6%	9.7%	9.5%

*High priority critically important antimicrobials (HP-CIAs) are: cefovecin, ciprofloxacin, enrofloxacin, marbofloxacin, ofloxacin, orbifloxacin and pradofloxacin

[Data Source: The Small Animal Veterinary Surveillance Network (SAVSNET)]

In 2020, among the participating veterinary practices, 16.2% of consultations for all companion animals resulted in the prescription of at least one antimicrobial (**Figure 12**). This is a year-on-year decrease of 4.4% ($p<0.001$) since 2016 but remained stable between 2019 and 2020 ($p=0.62$). There has also been a year-on-year decrease in the percentage of antimicrobials prescribed which were HP-CIAs (2.8%, $p <0.001$) for all companion animals between 2016 and 2020 (**Figure 12**).

Figure 12: Trends in prescribing of antimicrobials (including HP-CIA) for all companion animals, in Scottish practices, 2016 to 2020 inclusive.

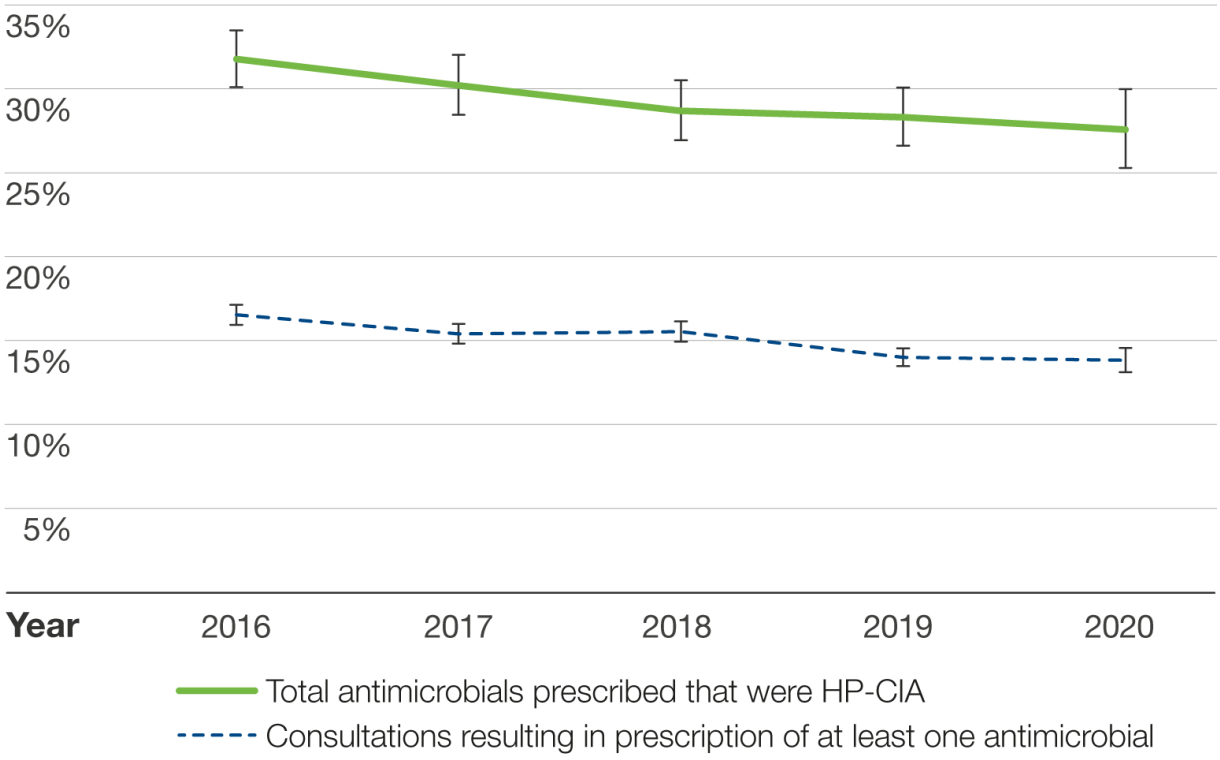


[Data Source: Small Animal Veterinary Surveillance Network (SAVSNET)]

The following figures summarise overall trends in aspects of AMU for cats and dogs in veterinary practices submitting to SAVSNET for 2016 to 2020. These include antimicrobials prescribed, routes of administration and main reasons for consultation. It is important to be aware of the contextual realities of veterinary practice when interpreting this information: e.g. some species are notoriously difficult to medicate by some routes of administration; for some species there is a very limited range of therapeutic options due to either or both toxicity and licensing of products for use in a particular species.

Between 2016 and 2020, there has been a year-on-year decrease in the percentage of consultations for cats which resulted in the prescription of at least one antimicrobial (4.6%, p<0.001) and also a year-on-year decrease in the percentage of antimicrobials prescribed for cats which were HP-CIAs (3.6%, p<0.001) (**Figure 13**).

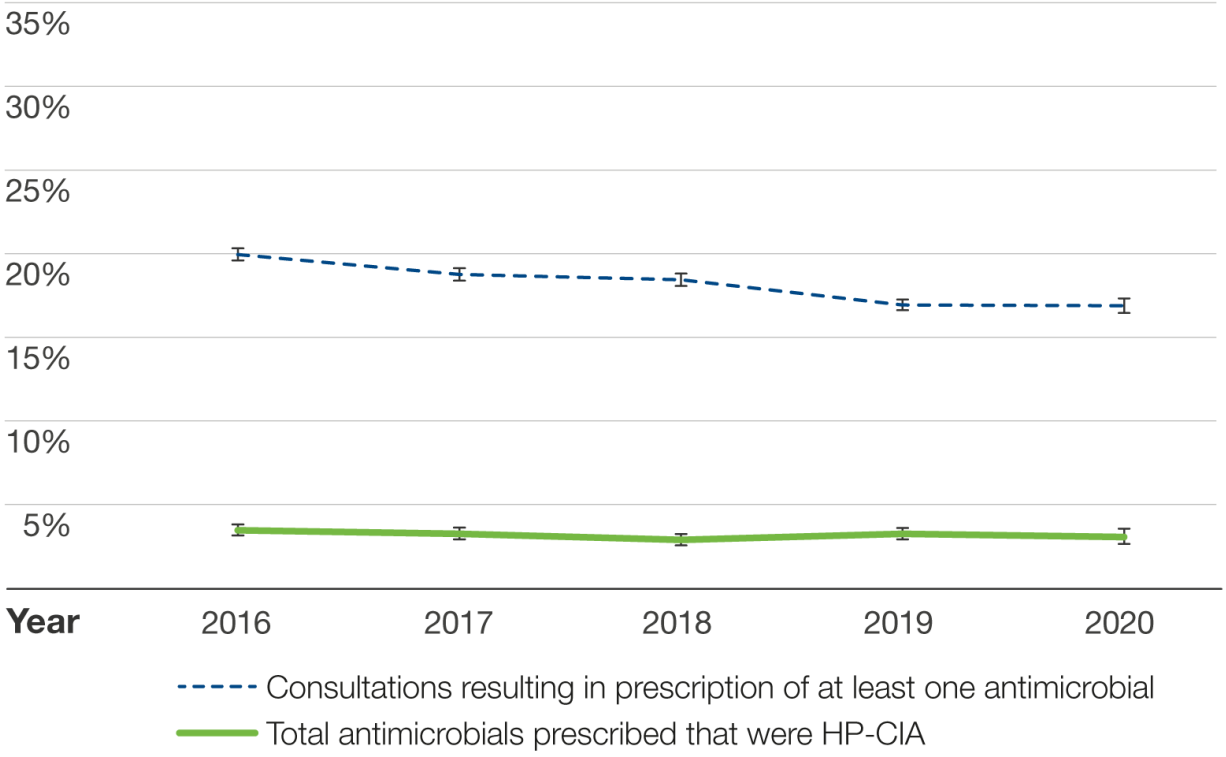
Figure 13: Trends in prescribing of antimicrobials (including HP-CIA) for cats, in Scottish practices, 2016 to 2020 inclusive.



[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

Between 2016 and 2020, there has been a year-on-year decrease in the percentage of consultations for dogs which resulted in the prescription of at least one antimicrobial (4.5%, p<0.001) but there has been no change (p=0.14) in the percentage of antimicrobials prescribed for dogs which were HP-CIAs (**Figure 14**).

Figure 14: Trends in prescribing of antimicrobials (including HP-CIA) for dogs, in Scottish practices, 2016 to 2020 inclusive.

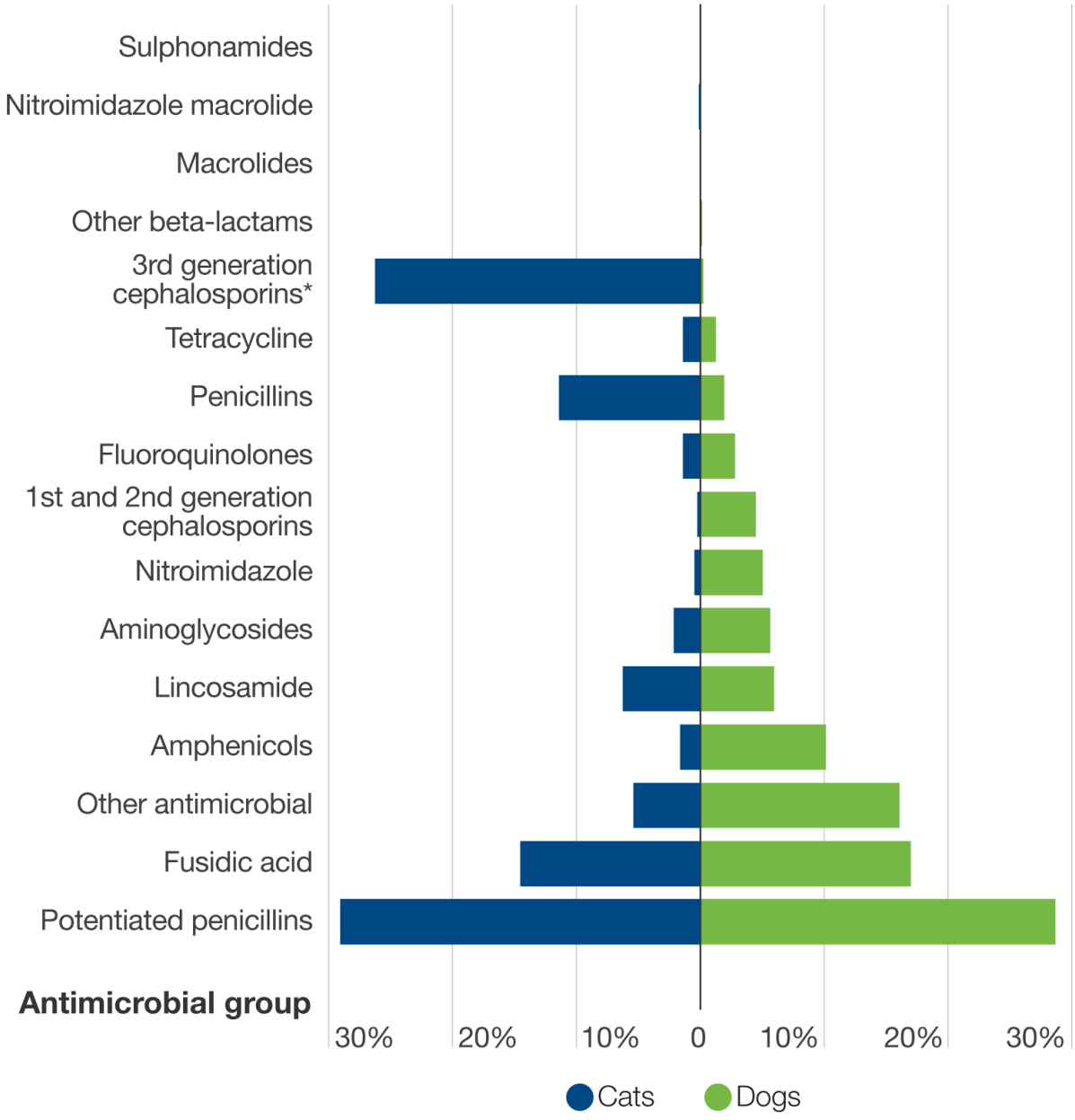


[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

Antimicrobial groups

The most frequently prescribed antimicrobial group was potentiated penicillins for cats (29.1%) and dogs (28.7%), followed by third generation cephalosporins for cats (26.3%) and topical antibiotic fusidic acid for cats (14.5%) and dogs (17.0%) (**Figure 15**).

Figure 15: Percentage of total antimicrobials prescribed, by antimicrobial family, for cats and dogs for 2020.



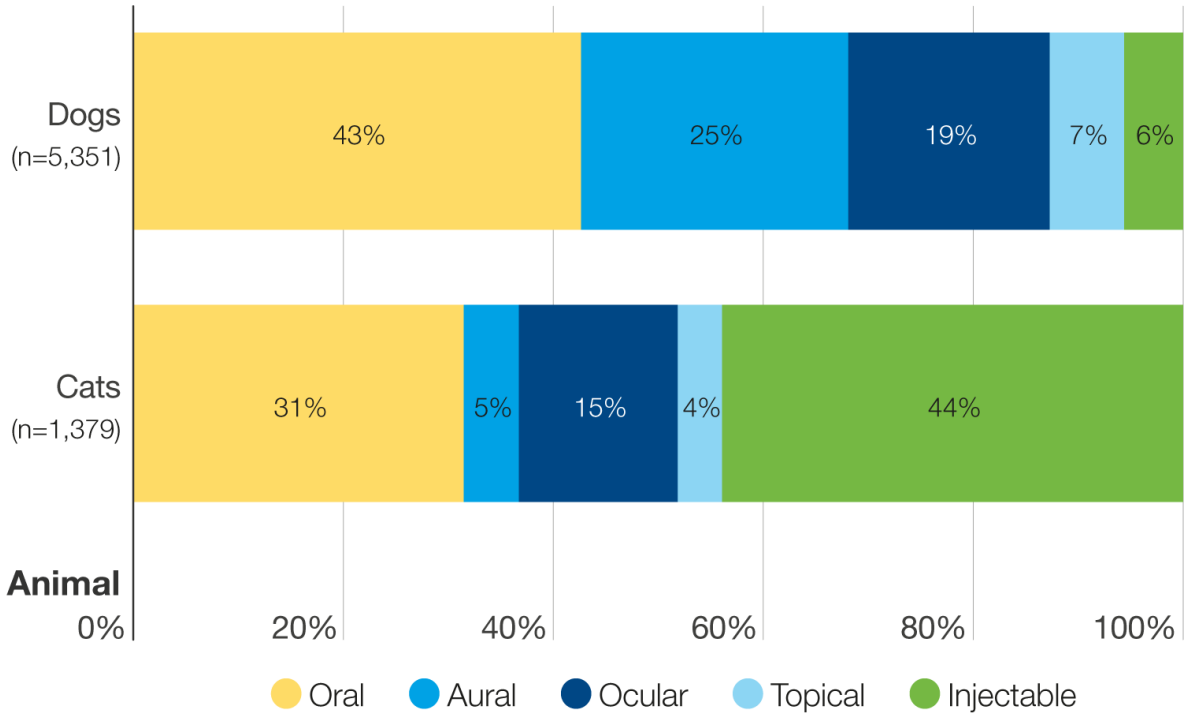
*3rd generation cephalosporins are usually categorised as part of a '3rd/4th/5th generation cephalosporin 'grouping, but no 4th or 5th generation cephalosporins are used in animals.

[Data Source: Small Animal Veterinary Surveillance Network (SAVSNET)]

Route of Administration

The route of administration of antimicrobials for dogs and for cats are shown in **Figure 16**. This is likely to reflect differences in the ease of medication by some routes of administration. For cats, the injectable route of administration was most common (43.9%). In contrast, for dogs, oral route of administration was most common (42.6%).

Figure 16: Route of administration of antibiotics for cats and dogs, 2020.



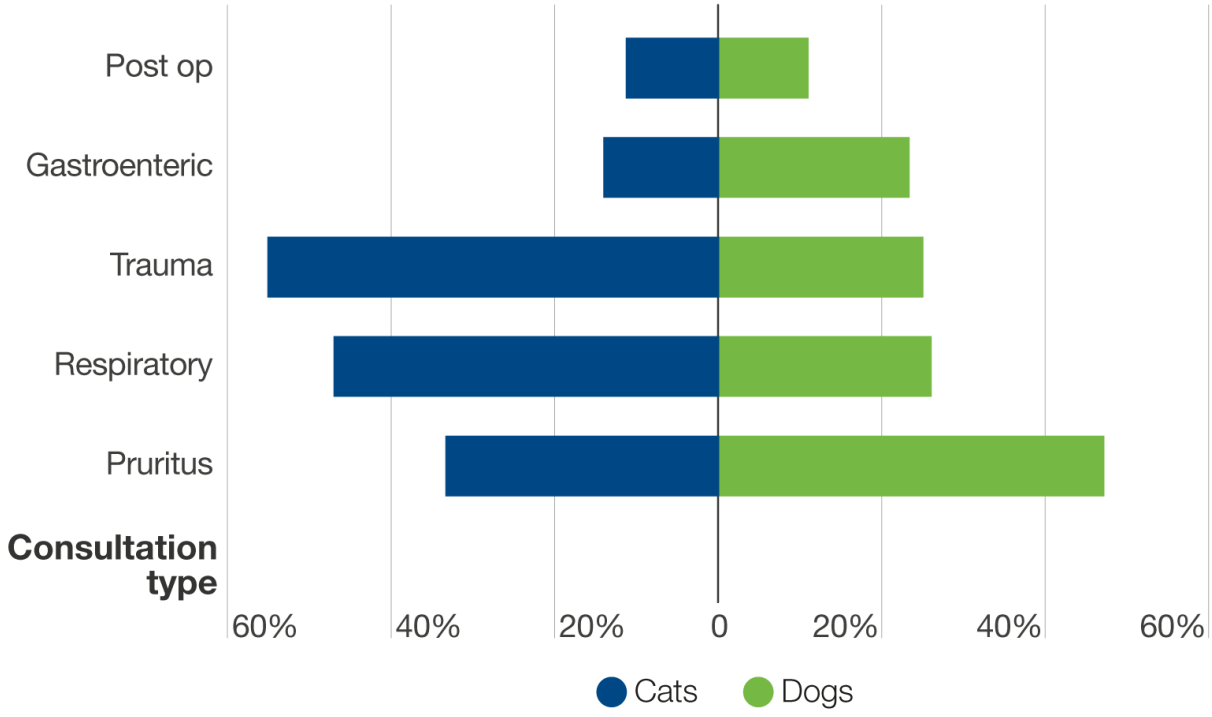
The following routes of administration were excluded from the visualisation but not the dataset: Dogs: unknown (n=1), intramammary (n=2), Cats: Unknown (n=1)

[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

Prescription of antimicrobial by syndrome

Figure 17 shows the percentage of consultations by the main presenting syndrome that resulted in prescription of an antimicrobial in cats and dogs; **Figure 18** and **Figure 19** focus on the importance of topical treatment of pruritus without recourse to systemic therapy.

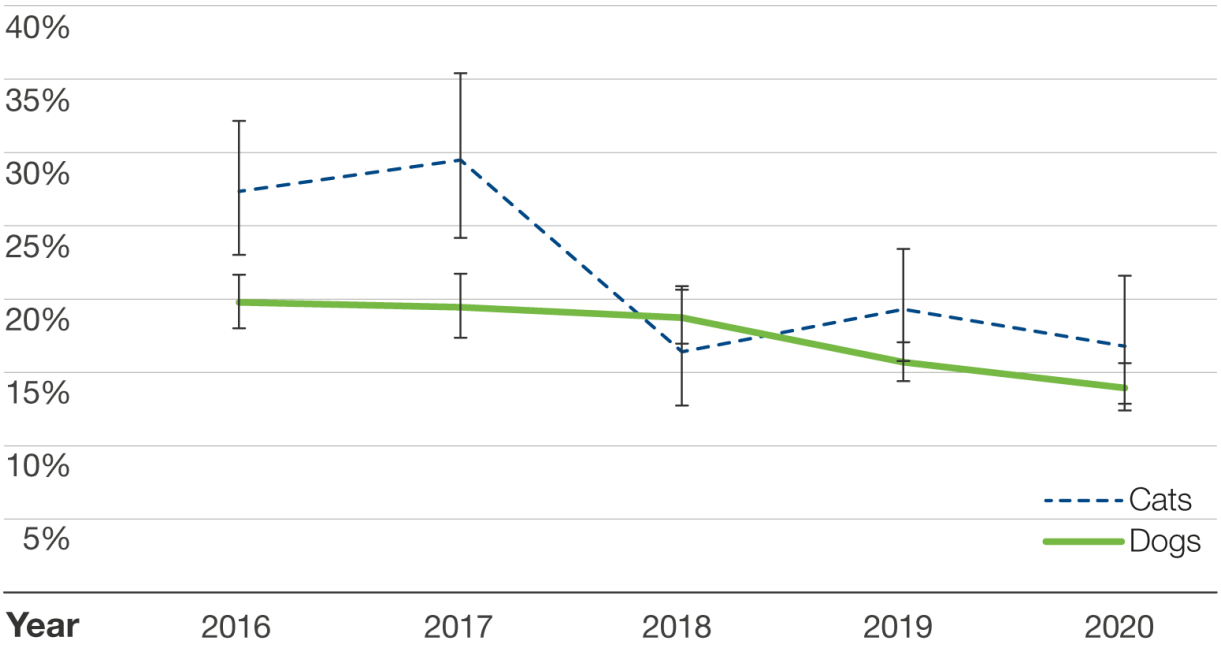
Figure 17: Percentage of consultations which resulted in prescription of an antimicrobial by main presenting syndrome for cats and dogs for 2020.



[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

Between 2016 and 2020, there has been a year-on-year decrease in the percentage of pruritus consultations for cats which resulted in the prescription of systemic antimicrobial (13.1%, $p<0.001$); there has also been a year-on-year decrease in the percentage for dogs (8.4%, $p<0.001$) (**Figure 18**).

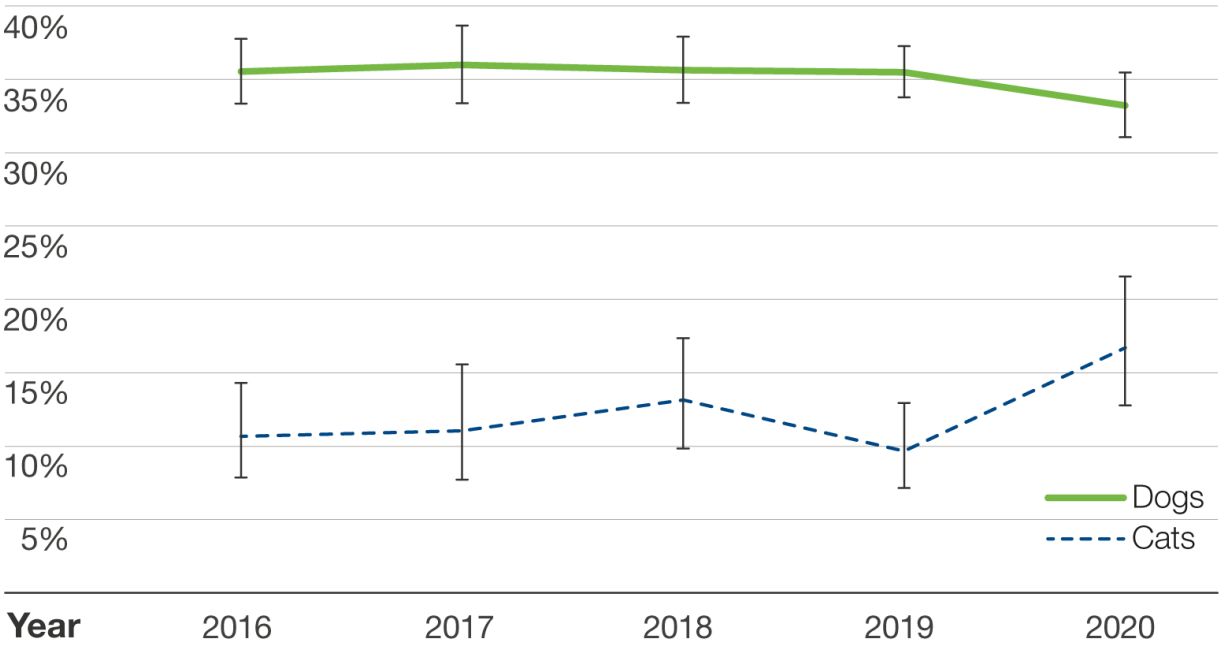
Figure 18: Proportion of pruritus consultations during which antibiotics authorised for systemic administration were prescribed for cats and dogs, 2016 to 2020.



[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

In contrast, between 2016 and 2020, the percentage of pruritus consultations for cats and dogs which resulted in the prescription of topical antimicrobial remained stable for cats (p=0.12) and dogs (p=0.22) (**Figure 19**).

Figure 19: Proportion of pruritus consultations during which antibiotics authorised for topical administration were prescribed for cats and dogs, 2016 to 2020.



[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

For further information on prescribing patterns by other types of consultations for cats and dogs, see Appendix.

Positive steps to recording farm level antimicrobial use in Scotland

Antimicrobials are crucial in supporting health and welfare, but their widespread use in livestock might contribute to antimicrobial resistance. Farm-specific health planning in collaboration with the farm vet, the nutritionist and other specialist consultants can reduce antimicrobial use at farm level while safeguarding animal health and welfare. Continuous monitoring through a dynamic health planning process will increase understanding of antimicrobial use on farms and help to identify any issues. Specific and realistic targets can be set and actions taken to lower antimicrobial use. Preventative, husbandry and biosecurity measures, and use of diagnostics for treatment decision making, can optimise and reduce antimicrobial use on farms. In order to support farmers, farm vets and other specialist consultants involved in flock/herd health planning Scotland's Rural College (SRUC) Veterinary Services have developed web-based software Scottish Animal Health Planning System (SAHPS) and an associated data capture phone app. The app, which links to SAHPS, allows farm data to be entered quickly, easily and shared with the vet and consultants in real time. The development and maintenance of SAHPS and the supporting app have been supported by the Scottish Government and both are free to Scottish veterinary practices and farmers. For further information visit the SAHPS website.

Animal Antimicrobial Use Key Points

- **Overall antimicrobial use in companion animals is reducing over time in Scotland.**
- **Antimicrobials are very important medicines in animal species and ongoing data collection contributes to developing the evidence base pertaining to AMU in animals and their impact on AMR.**
- **Engagement and support from animal stakeholder groups is essential in the development of this intelligence.**
- **Further close working with SAVSNET to encourage practices to participate in the network is important.**
- **Scotland's Healthy Animals website provides guidance for vets and animal keepers on disease avoidance and antimicrobial stewardship.**

What is the current burden of drug resistant infections in Scotland?

Reducing the burden of drug resistant infections is critical to controlling AMR by reducing the need for antimicrobials and reducing the risk of further spread of drug resistant micro-organisms.

In 2020, there were an estimated 1,312 bloodstream infections (BSI) caused by antibiotic resistant bacteria of public health concern compared to 1,476 in 2019 (**Table 2**). There were 1,133 and 179 Gram-negative and Gram-positive antibiotic resistant bacteraemia, respectively. Drug resistant bacteraemia caused by Gram-negative bacteria accounted for 86.4% of all drug resistant bacteraemia. Importantly, nearly a quarter of *Escherichia coli* bacteraemia (ECB) in Scotland were resistant to one or more key antibiotics, accounting for over 977 cases. Whilst *Escherichia coli (E. coli)* accounted for the majority of drug resistant infections, vancomycin resistant *Enterococcus faecium* (*E. faecium*) were the second most common organism. The overall burden of infection was low; however, the proportion of resistance to vancomycin was 45.6%.

Table 2: Estimated number of drug resistant bacteraemia in Scotland, 2020, by organism.

Organisms (n=total number of bacteraemia)	Percentage resistant to at least one key antibiotic	Estimated number of resistant bacteraemia
Gram-negative bacteraemia (n=5,462)	**20.7%**	**1,133.1**
Escherichia coli (n=4,206)	23.2%	976.7
Klebsiella pneumoniae (n=729)	16.5%	120.1
Klebsiella oxytoca (n=204)	4.7%	9.6
Acinetobacter species (n=67)	1.6%	1.1
Pseudomonas aeruginosa (n=256)	10.0%	25.5
Gram-positive bacteraemia (n=2,493)	**6.3%**	**179.1**
Enterococcus faecium (n=290)	45.6%	132.3
Enterococcus faecalis (n=463)	0.5%	2.1
Staphylococcus aureus (n=1,501)	2.6%	39.0
Streptococcus pneumoniae (n=239)	2.4%	5.7
Total number of bacteraemia (n=7,955)	**16.5%**	**1,312.1**

[Data source: Electronic Communication of Surveillance in Scotland (ECOSS)]

Burden of AMR Key Points

- **Reducing the burden of drug resistant infections is critical to controlling and containing AMR.**
- **There were an estimated 1,312 drug resistant bacteraemia in 2020.**
- **86.4% of drug resistant bacteraemia were caused by Gram-negative bacteria.**
- **Continued focus on reducing Gram-negative infections is essential.**
- **Gram-positive infections also contribute to the burden of AMR.**
- **Robust intelligence and metrics are required to plan, prioritise and evaluate interventions to reduce the burden.**

Antimicrobial Resistance

Antimicrobial resistance in humans

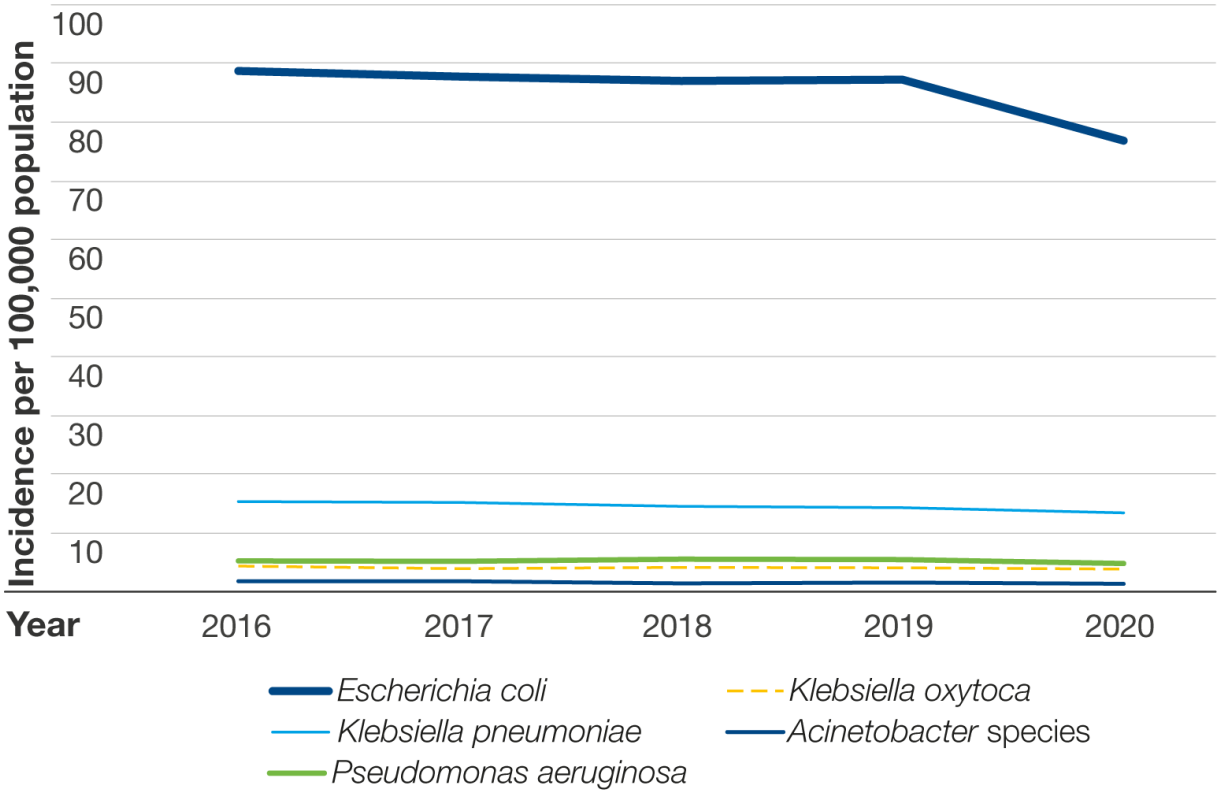
AMR is a serious worldwide public health challenge, threatening the effective prevention and treatment of an ever-increasing number of pathogens. Although resistance occurs naturally, the inappropriate use of antimicrobials amplifies the rate at which it develops and spreads.[13] With a limited pipeline of new antimicrobials under development, AMR renders once standard treatments ineffective and is associated with increased morbidity and mortality, longer treatment durations and higher healthcare costs.[14]

Surveillance data, as presented in this report, provides essential evidence to prevent, control and contain AMR, drive appropriate prescribing, inform national policy and preserve the effectiveness of antibiotics for future generations.

Gram-negative bacteraemia

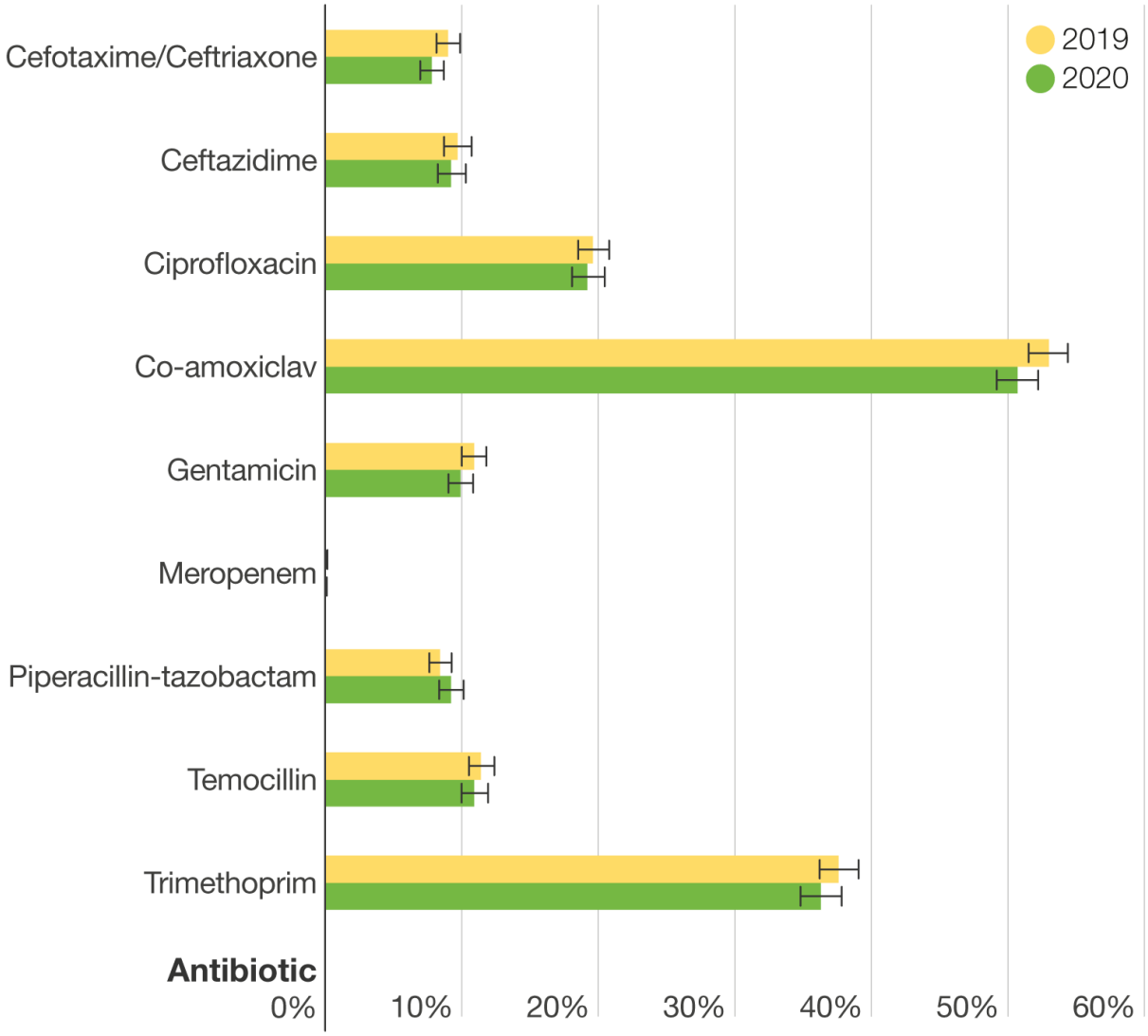
Gram-negative bacteria are an important cause of serious infections in both healthcare and community settings. In the United Kingdom one of the biggest drivers of resistance is a rise in the incidence of infections, particularly Gram-negatives.[15] In 2020 *E. coli* was the most common cause of Gram-negative bacteraemia in Scotland with 4,206 cases reported and a rate of 76.9 per 100,000 population (**Figure 20**). The rate of ECB in Scotland has decreased 11.8% ($p<0.01$) between 2019 and 2020, and has decreased 2.8% ($p<0.01$) over the last five years. Non-susceptibility in ECB isolates has remained stable between 2019 and 2020 (**Figure 21**).

Figure 20: Incidence of Gram-negative bacteraemia per 100,000 population in Scotland, 2016 to 2020, by five most frequently reported organism and year.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and National Records of Scotland (NRS)]

Figure 21: Non-susceptibility of *E. coli* bacteraemia isolates in Scotland, 2019 to 2020.



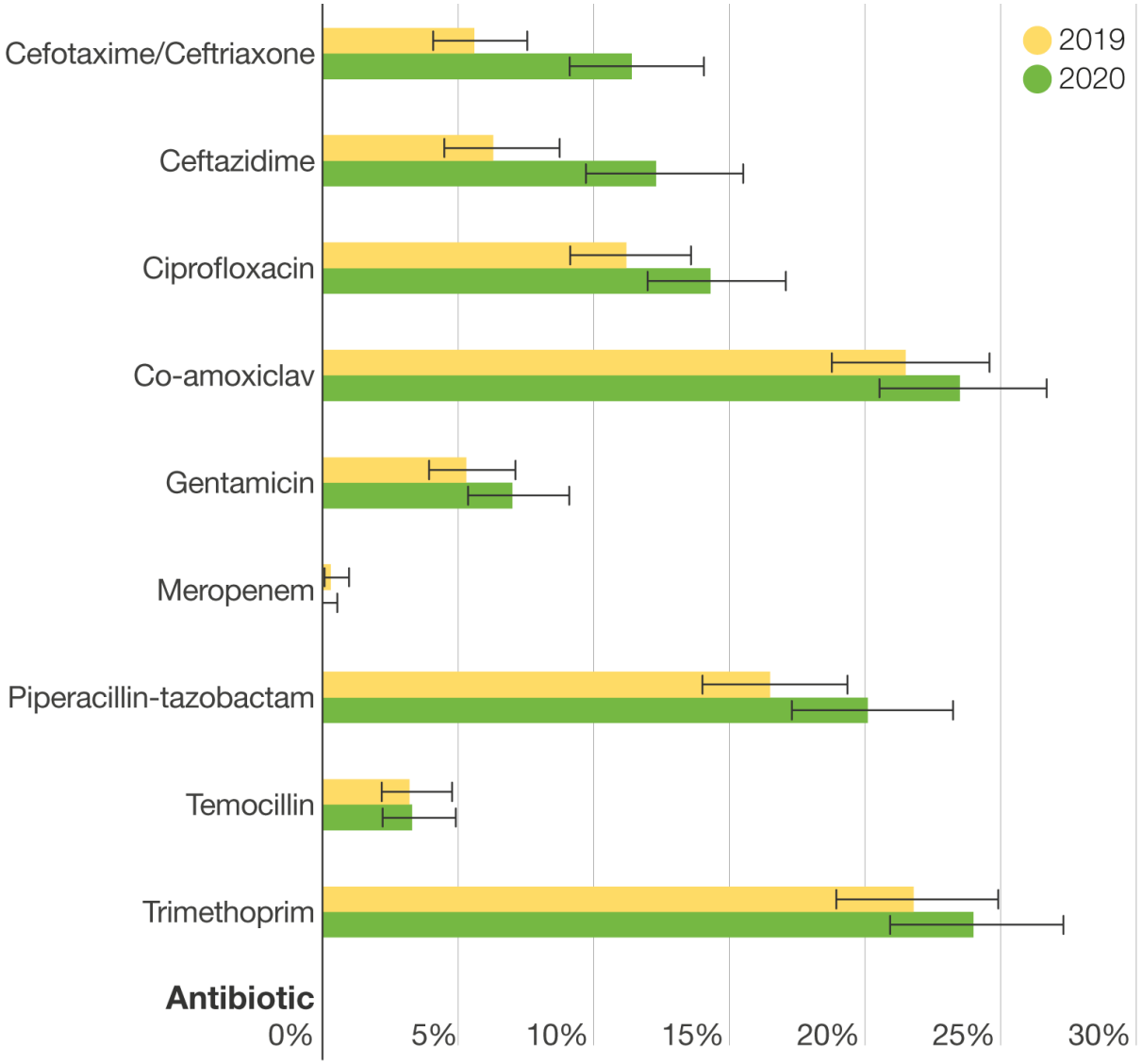
[Data source: Electronic Communication of Surveillance in Scotland (ECOSS)]

Since 2016, the rate of bacteraemia caused by *Klebsiella pneumoniae* (*K. pneumoniae*), *Pseudomonas aeruginosa* (*P. aeruginosa*), *Klebsiella oxytoca* (*K. oxytoca*) and *Acinetobacter* species has remained stable (**Figure 20**). Despite their collective incidence being lower than that of *E. coli* bacteraemia alone, *K. pneumoniae, P. aeruginosa, K. oxytoca* and *Acinetobacter* species still represent a significant burden of infection.

729 cases of *K. pneumoniae* bacteraemia were reported during 2020 with a rate of 13.3 per 100,000 population. *K. pneumoniae,* are an important cause of healthcare associated infection (HCAI), especially urinary tract infections (UTIs), respiratory tract infections and BSIs.[16]

Clinical management of *Klebsiella* infections is becoming increasingly difficult due to antimicrobial resistance, particularly with regards to acquired carbapenemases.[17] Non-susceptibility of *K. pneumoniae* blood isolates remained stable between 2019 and 2020, apart from an increase in cefotaxime/ceftriaxone and ceftazidime (**Figure 22**).

Figure 22: Non-susceptibility of *K. pneumoniae* bacteraemia isolates in Scotland, 2019 to 2020.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS)]

As an opportunistic pathogen, *P. aeruginosa* is associated with a variety of acute and chronic infections and is a leading cause of hospital-acquired infections, particularly in immunocompromised patients.[18] *P. aeruginosa* is not only intrinsically resistant to a broad range of antibiotics but can easily develop additional resistance via chromosomal mutations or horizontal acquisition of resistance determinants.[19] In 2020, there were 256 cases of *P. aeruginosa* bacteraemia in Scotland with a rate of 4.7 per 100,000. Non-susceptibility in *P. aeruginosa* blood isolates has remained stable ($p>0.05$) between 2019 and 2020 (see **Appendix**).

AMR in Gram-negative Bacteria Key Points

- **Gram-negative bacteria are a common cause of serious infection in both healthcare and community settings.**
- **AMR in Gram-negative bacteria significantly contributes to the overall burden of AMR.**
- ***E. coli* is the most common cause of Gram-negative bacteraemia and contributes significantly to the burden of AMR.**
- **Since 2019, non-susceptibility in ECB has remained stable.**
- **Since 2019, non-susceptibility of *K. pneumoniae* blood isolates to cefotaxime/ceftriaxone and ceftazidime has increased.**

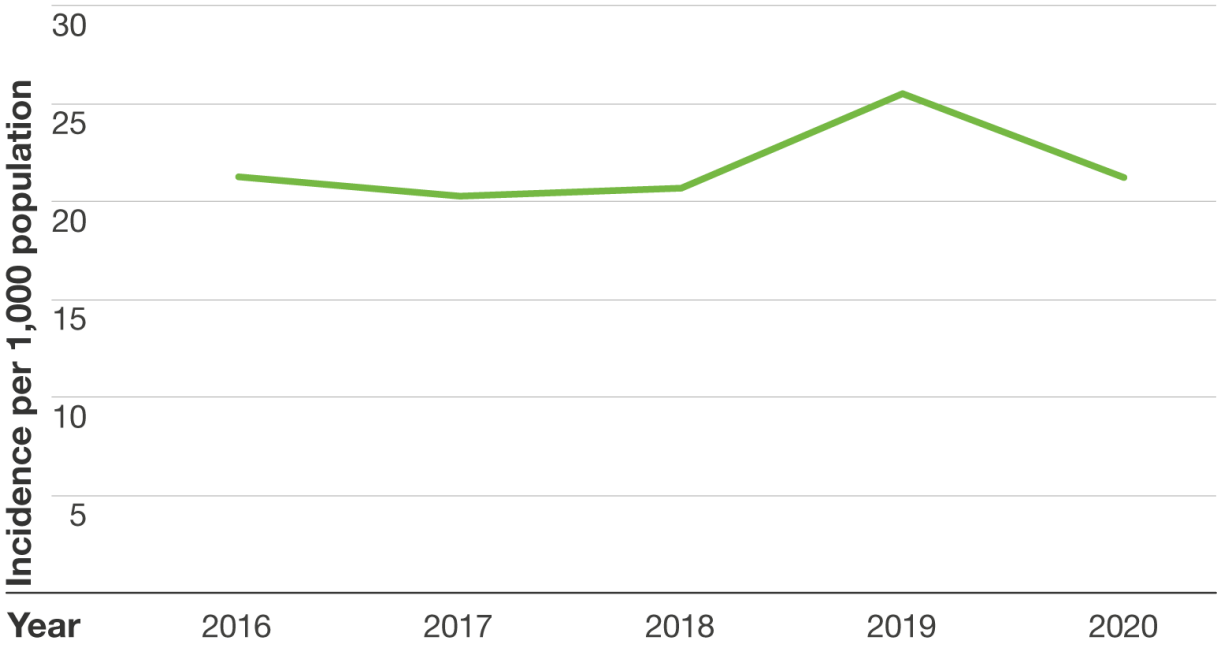
Urinary Tract Infections caused by *Escherichia coli*

Due to the high prevalence of UTIs in both community and healthcare settings, these constitute a significant public health priority. Frequent recurrence rates and increasing antibiotic resistance among urinary bacteria threaten to increase the burden of these infections. In turn, the development of resistance in urinary isolates can act as an early warning of resistance in bacteria causing more serious infections.[20] Increasing resistance necessitates judicious use of antibiotics. Knowledge of the common causative pathogens, including local susceptibility patterns, is essential in determining appropriate empiric therapy.[21]

In 2020, 25.9% of ECB were due to primary UTIs,[7] therefore, to achieve significant reductions in morbidity and mortality caused by ECB, interventions aimed at preventing UTI are necessary. Recognising this burden of potentially preventable UTI and catheter associated UTI (CAUTI); the Scottish UTI Network (SUTIN) was established in 2015. The purpose is to provide seamless care for people with urinary catheters as they move across various health and social care settings. COVID-19 has restricted the activities of the SUTIN however all resources developed to target UTI reduction strategies in collaboration with health and social care continue to be available. The National Hydration Adult and Children's Think2DrinkH2O campaigns, and the National Catheter Passport are examples of this collaborative approach to reducing UTI and CAUTI. These resources support reduction of ECB and prudent antimicrobial prescribing.

In 2020, there were 115,844 cases of *E. coli* from urine samples with a rate of 21.2 per 1,000 population (**Figure 23**). The incidence of *E. coli* urinary isolates has decreased 16.9% between 2019 and 2020. This decrease may be attributed to a reduction in sampling as a result of the impact of the COVID-19 pandemic and the implementation of **NHS Pharmacy First Scotland** as described in the section on **Antimicrobial use in primary care**. Between 2019 and 2020, antimicrobial non-susceptibility in *E. coli* urinary isolates remained stable apart from a decrease in co-amoxiclav and an increase in fosfomycin (**Figure 24**).

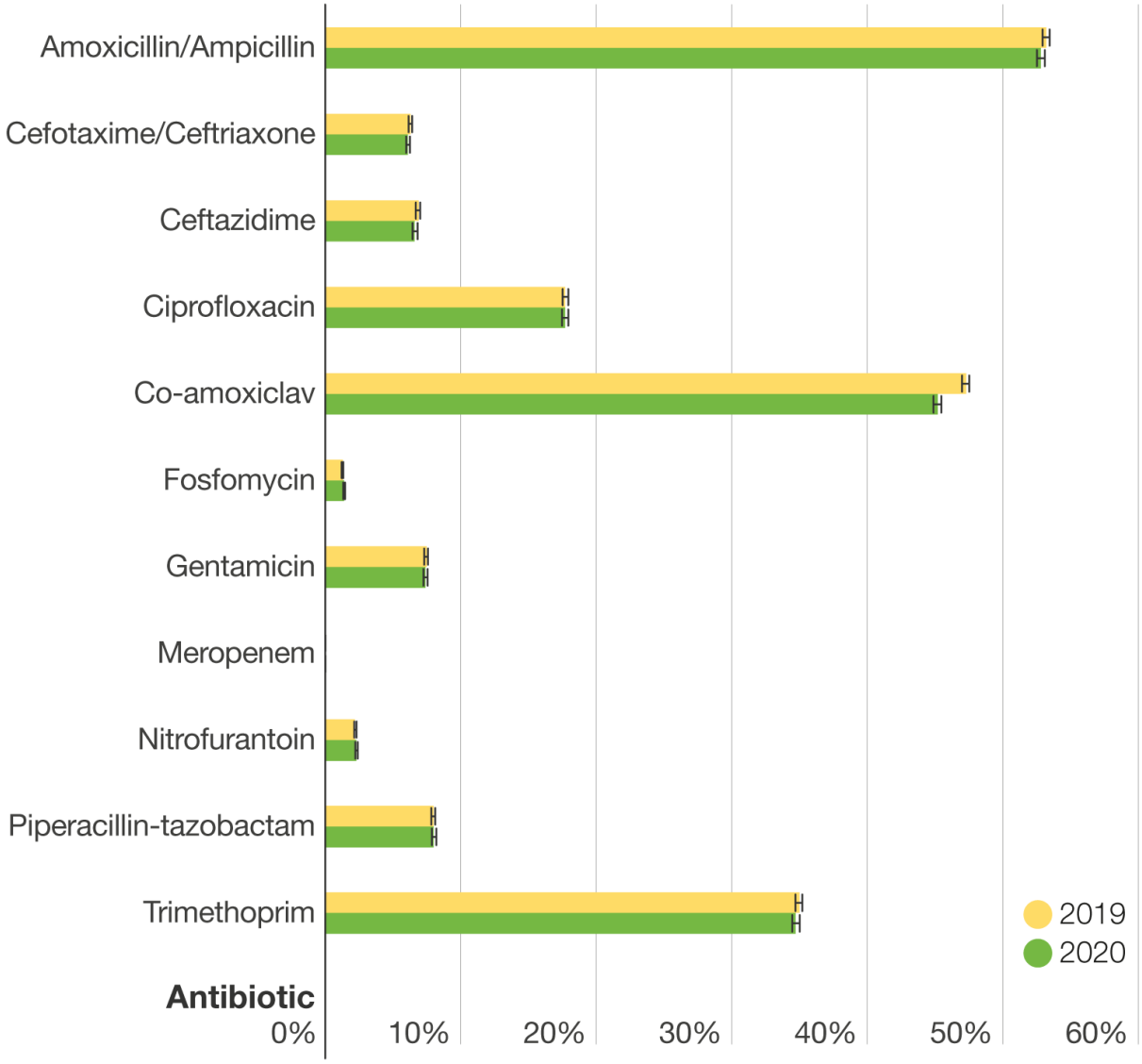
Figure 23: Incidence of *E. coli* urinary isolates per 1,000 population in Scotland, 2016 to 2020.



Note: Denominator per 1,000 population due to large numbers

[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and National Records of Scotland (NRS)]

Figure 24: Non-susceptibility of *E. coli* urinary isolates in Scotland, 2019 to 2020.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS)]

AMR in Urinary Tract Infections Key Points

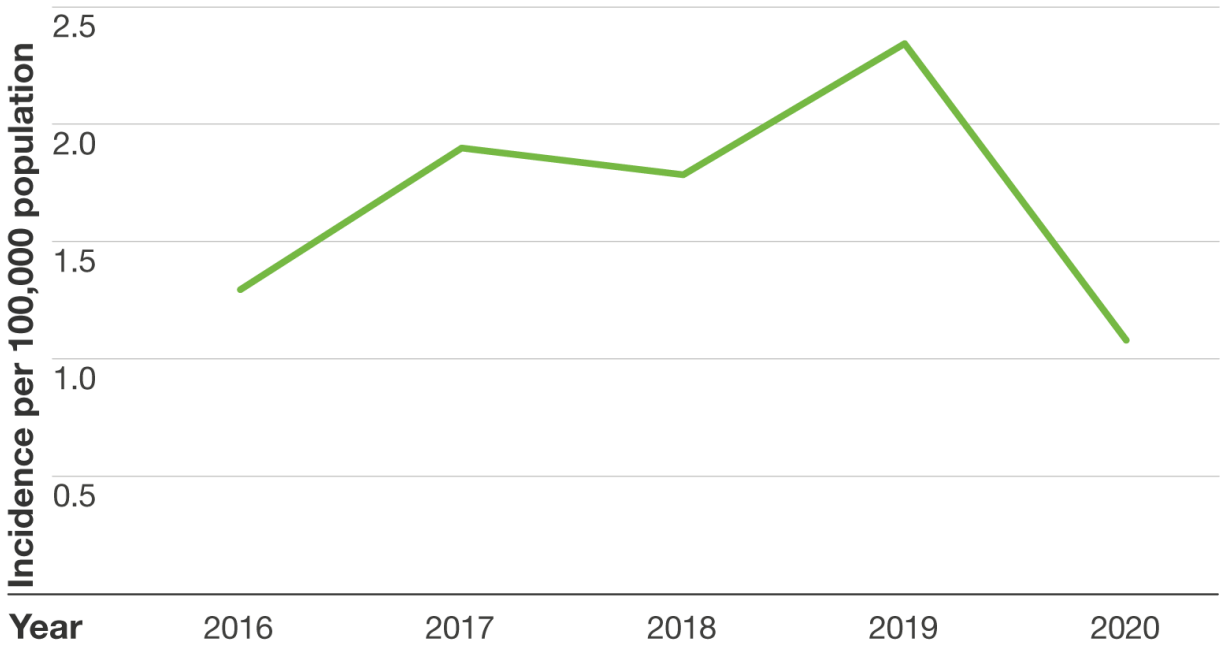
- **UTIs are commonly diagnosed in community and healthcare settings.**
- **AMR in urinary isolates significantly adds to the burden of AMR.**
- ***E. coli* is the most common bacteria isolated from urine specimens.**
- **The rate of *E. coli* UTI has decreased 16.9% between 2019 and 2020.**
- **Between 2019 and 2020, non-susceptibility of *E. coli* urinary isolates remained stable apart from a decrease in co-amoxiclav and an increase in fosfomycin.**

Carbapenemase-producing organisms

Carbapenems are potent beta-lactam antibiotics with a broad spectrum of activity, often reserved as last-line agents for the treatment of bacterial infections.[22] Consequently, carbapenem resistance is of major and on-going public health concern, particularly in Gram-negative bacteria where the primary mechanism of resistance is the production of acquired carbapenemases, enzymes which inactivate carbapenem antibiotics.[23] Carbapenemase enzymes hydrolyse a broad variety of β-lactams, with few exceptions and are often carried on mobile genetic elements allowing for horizontal transfer between strains, species and genera.[23;24]

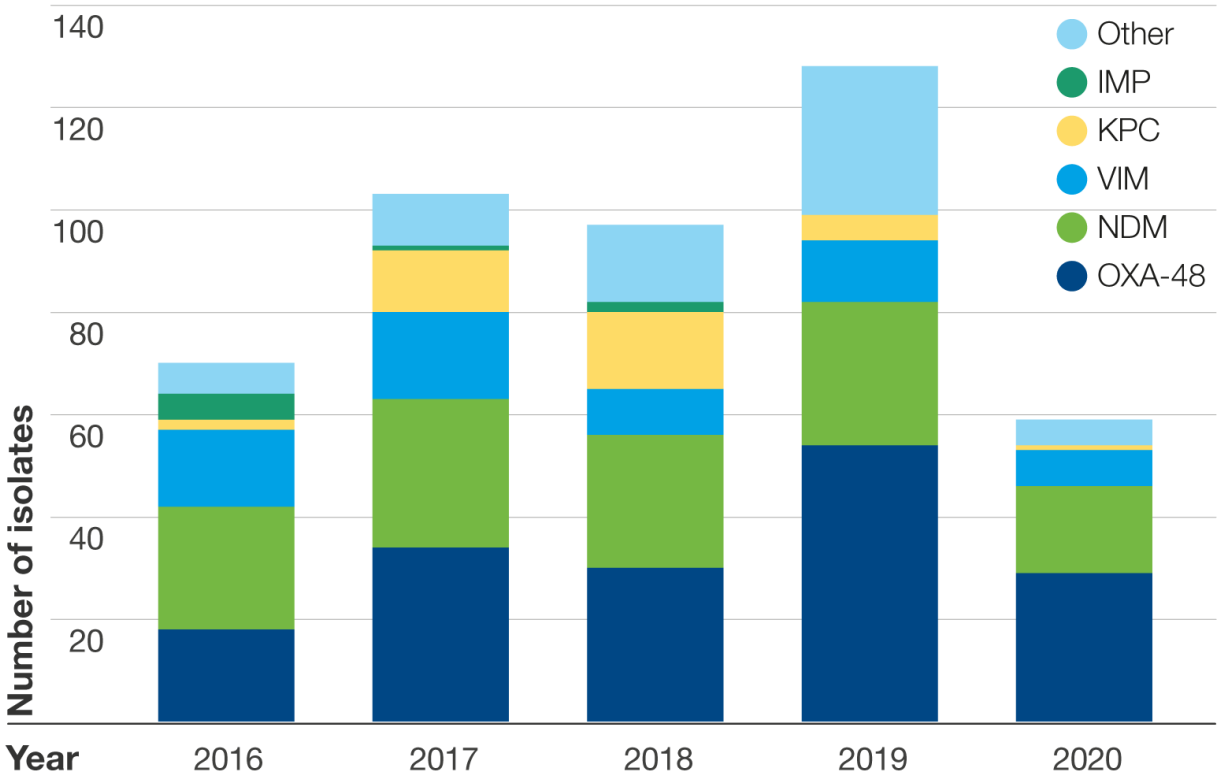
In 2020, 59 carbapenemase-producing organisms (CPO) were reported with a rate of 1.1 per 100,000 population. This compares to 128 CPOs in 2019 with a rate of 2.3 per 100,000 population. The rate of CPO has decreased 53.9% between 2019 and 2020 (**Figure 25**). This decrease may be attributed to the impact of the COVID-19 pandemic, with a reduction in foreign travel and changes in hospital activity. The majority of CPO identified were carbapenemase-producing *Enterobacterales* (CPE), (n= 56, 94.9%), and the remaining were non-fermenters such as *Acinetobacter* spp. and *P. aeruginosa*. In 2020 the most frequently identified enzyme genes were oxacillinase (OXA)-48 followed by New Delhi Metallo-beta-lactamase (NDM) and Verona integrin-encoded metallo-beta-lactamase (VIM) (**Figure 26**).

Figure 25: Incidence of CPOs per 100,000 population in Scotland, 2016 to 2020.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and National Records of Scotland (NRS)]

Figure 26: Number of CPO isolates (first isolation from all body sites) reported in Scotland, 2016 to 2020, by enzyme type and year.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and Scottish Microbiology Reference Laboratory (SMiRL)]

Enterococcal bacteraemia

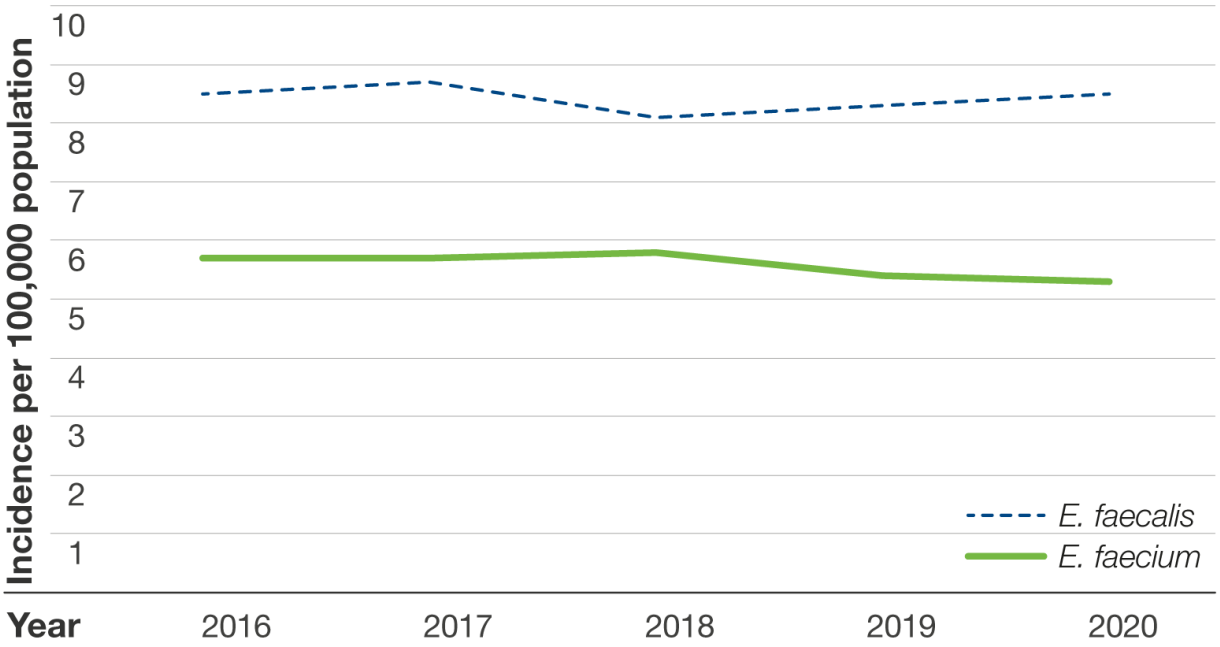
As commensals of the gastrointestinal tract in both humans and animals, enterococci are opportunistic pathogens capable of causing a range of infections including UTIs, wound infections, bacteraemia and endocarditis.[25] In humans, the majority of infections are caused by *Enterococcus faecalis (E. faecalis)* and *E. faecium.* Enterococci are well established as a leading cause of HCAIs and their success is due, in part, to their intrinsic resistance and capacity to rapidly acquire and disseminate resistance genes coupled with their ability to survive in harsh environments.[26;27]

In 2020, 463 cases of *E. faecalis and* 290 *cases of E. faecium* bacteraemia were reported in Scotland. The rate of *E. faecalis* bacteraemia (8.5 per 100,000 population) *and E. faecium*

bacteraemia (5.3 per 100,000 population) has remained stable (p>0.05) since 2016 (**Figure 27**).

Non-susceptibility of *E. faecium* blood isolates remained stable (p>0.05) between 2019 and 2020. However, according to the latest surveillance data from 2019,[28] Scotland has one of the highest (45.6%) reported vancomycin non-susceptibility proportions in Europe with other countries reporting between 0.0% and 50.0%. Infections caused by vancomycin resistant enterococci (VRE) are associated with higher mortality rates compared with those cause by vancomycin sensitive enterococci (VSE).[25] There are a number of factors known to increase the risk of infection with VRE including previous antibiotic therapy, previous/prolonged hospitalisation, medical devices and severe underlying illnesses or immunosuppression.[25] The SONAAR programme will undertake further analysis and will work with stakeholders to identify appropriate public health actions.

Figure 27: Incidence of *E. faecalis* and *E. faecium* bacteraemia per 100,000 population in Scotland, 2016 to 2020, by organism and year.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and National Records of Scotland (NRS)]

AMR in *Enterococcus* species Key Points

- ***Enterococcus* species have the ability to survive in harsh environments.**
- **Incidence of *E. faecalis* and *E. faecium* bacteraemia has remained stable between 2016 and 2020.**
- **Non-susceptibility in *E. faecium* blood isolates has remained stable between 2019 and 2020.**
- **45.6% of *E. faecium* blood isolates were non-susceptible to vancomycin.**
- **Further work is required to identify the appropriate public health actions.**

Exceptional resistance identified through the AMR Alerts Early Warning System (AMR-EWS) in 2020

National monitoring of exceptional phenotypes enables a timely scientific and public health response to potential emerging AMR issues. Detection of emerging AMR is critical to contain the development and spread of resistance at a national, regional and local level and allows ARHAI Scotland to gather intelligence relating to national trends and to communicate any identified issues with other public health bodies, as necessary.

The exceptional phenotypes monitored in the ARHAI Scotland AMR-EWS are also detailed in **Appendix 13** of the National Infection Prevention & Control Manual (NIPCM) as a mandatory alert micro-organism/condition list.[29] Local monitoring ensures that microbiology clinicians, infection prevention and control teams (IPCTs), health protection teams (HPTs) and antimicrobial management teams (AMT), as appropriate, are aware of each identified case as per local protocols.

In 2020, the total number of laboratory confirmed exceptional phenotypes identified from the EWS was 451 (see **Appendix**).

Exceptional Phenotype Monitoring Key Points

- **Monitoring of exceptional resistance is critical for identifying emerging AMR threats.**
- **National monitoring is essential for collating and developing epidemic intelligence.**
- **Monitoring emerging exceptional phenotypes enables the development of appropriate public health action.**

Antimicrobial resistance in humans and animals: *Salmonella* in Scotland

Salmonella is a Gram-negative bacterium, ubiquitous in nature and a common cause of gastrointestinal illness in humans. It is the second most commonly reported cause of bacterial infectious intestinal disease in Scotland after *Campylobacter* spp.[30] *Salmonella* is usually a self-limiting infection and treatment with antibiotics is not routinely recommended. However, in some individuals, antimicrobial therapy may be required, particularly for severe or extraintestinal infections.

Salmonella is a zoonosis - a wide range of domestic and wild animals can act as a reservoir, including cattle, sheep, pigs, poultry, reptiles and household pets. Infected animals are often asymptomatic. In recent years, fresh produce such as fruits and vegetables have been recognised as vehicles of transmission,[31-33] where contamination can occur at multiple steps along the food chain. Feeder mice and reptiles have also been recognised as a source of *Salmonella* with related outbreaks.[34]

Salmonella is notifiable in humans and a reportable animal pathogen in the UK. All medical diagnostic laboratories are required to forward suspect isolates from humans to the Scottish Microbiology Reference Laboratory (SMiRL) which is responsible for testing antimicrobial susceptibility in a range of organisms, including *Salmonella* and *Shigella* species. All veterinary diagnostic laboratories isolating *Salmonella* spp. from livestock species are required to send suspect isolates for confirmation and typing to the SMiRL.

Prior to the beginning of 2020, human and animal *Salmonella* isolates were tested for antimicrobial susceptibility at SMiRL using an in-house agar plate breakpoint method providing AMR phenotype data for the defined set of 14 antimicrobials of veterinary and human health significance.

Whole genome sequencing (WGS) has been in routine use in the Scottish Microbiology Reference Laboratories for the identification and characterisation of Salmonella isolates since October 2017. Following a review of published reports[35;36] and an extensive validation confirming the high degree of correlation observed between the two approaches, the *in silico* prediction of AMR phenotype from WGS was introduced in January 2020. The predictive tools in use allow the identification of many thousands of individual AMR genes. New AMR mechanisms identified by other laboratories can quickly be identified by searching within the existing sequence dataset without the need to repeat the wet laboratory processes.

The availability of data from isolates from different source populations (humans and animals) processed in exactly the same way by the same laboratory offers an opportunity to monitor the trends in resistance and identify epidemiological links.

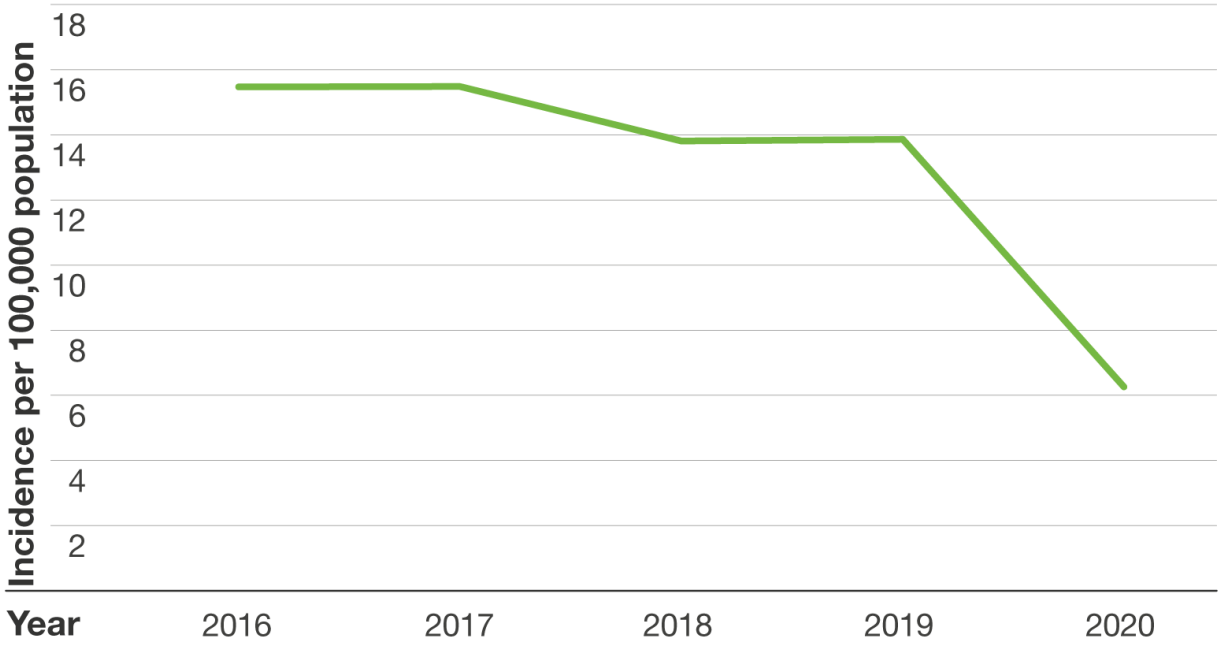
Human and animal non-typhoidal *Salmonella*

Human

In 2020, there were 342 confirmed laboratory reports of *Salmonella*, corresponding to an incidence of 6.3 cases per 100,000 population and is a significant decrease from the 13.9 cases per 100,000 population reported in 2019 (54.8%, $p<0.001$) (**Figure 28**). This reduction in cases is thought to be primarily the result of COVID-19 pandemic restrictions. The two most commonly reported serotypes were *Salmonella* Enteritidis and *Salmonella* Typhimurium which accounted for 33.6% and 23.4% of all *Salmonella* isolates reported in 2020. This figure is comparable with previous years: between 2014 and 2019, around 55% of reports were represented by these two serotypes.

Only 7% of cases in 2020 were thought to have acquired their infection abroad compared with 35% of cases in 2019 reporting foreign travel as a likely source of their infection. This is, however, an underestimation as Public Health Scotland (PHS) does not receive travel information for all cases.

Figure 28: Incidence of *Salmonella* species per 100,000 population in Scotland, 2016 to 2020.

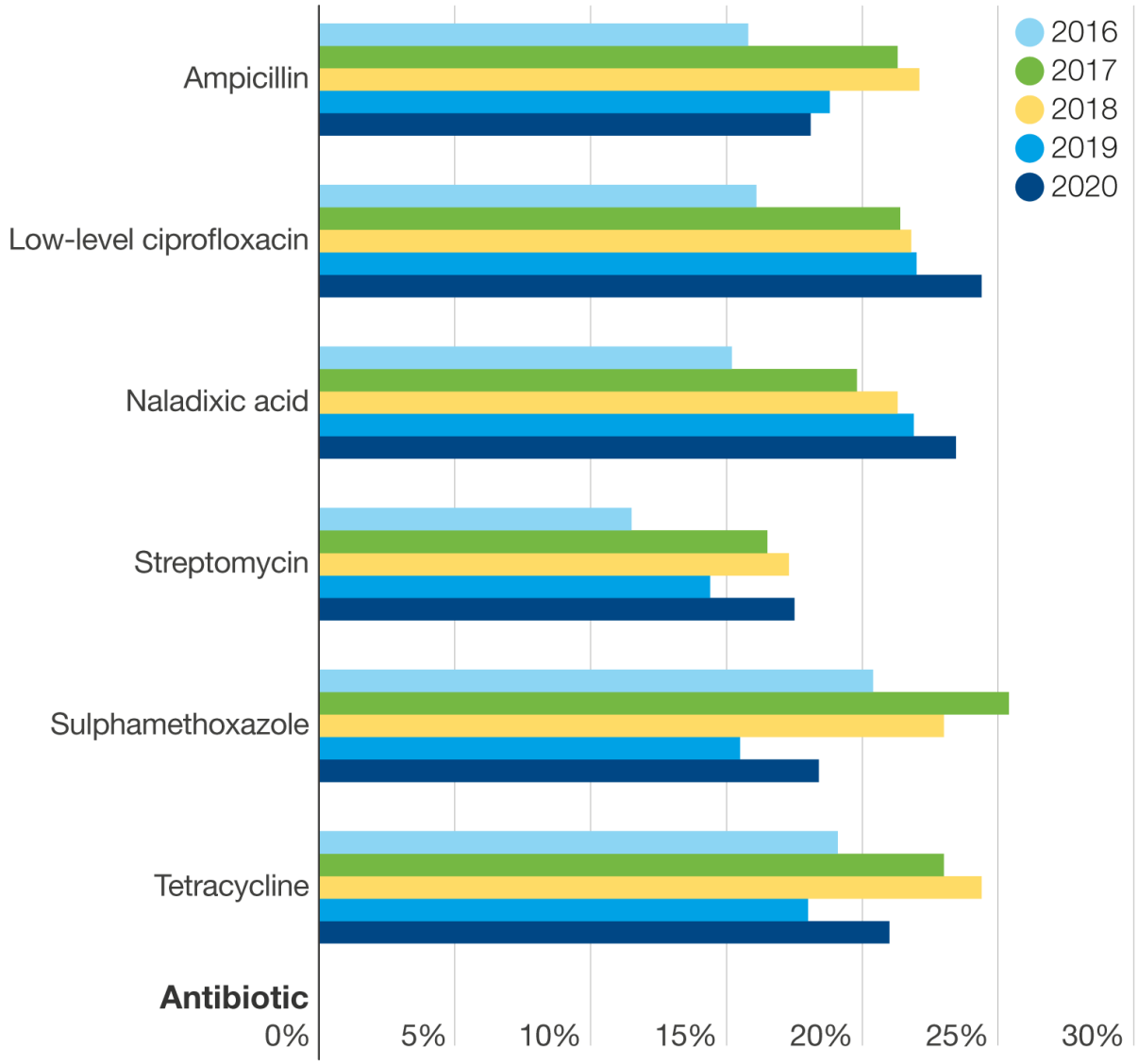


[Data source: Electronic Communication of Surveillance in Scotland (ECOSS) and National Records of Scotland (NRS)]

Susceptibility of human non-typhoidal *Salmonella*

In 2020, 60.2% of human *Salmonella* isolates were designated as fully susceptible due to the absence of any detectable AMR genes/genetic markers.

Figure 29: Non-susceptibility of human *Salmonella* isolates in Scotland, 2016 to 2020, by year.



[Data source: Scottish Microbiology Reference Laboratory (SMiRL)]

Interpretation of *Salmonella* resistance to individual antibiotics is complicated by the fact that in some subtypes there are well-recognised genetic elements encoding resistance to multiple agents. Thus, the occurrence of resistance to individual antibiotics is not always independent and the apparent prevalence of resistances to different agents can be strongly influenced by the abundance of *Salmonella* sub-types in the sample set for each reporting period.

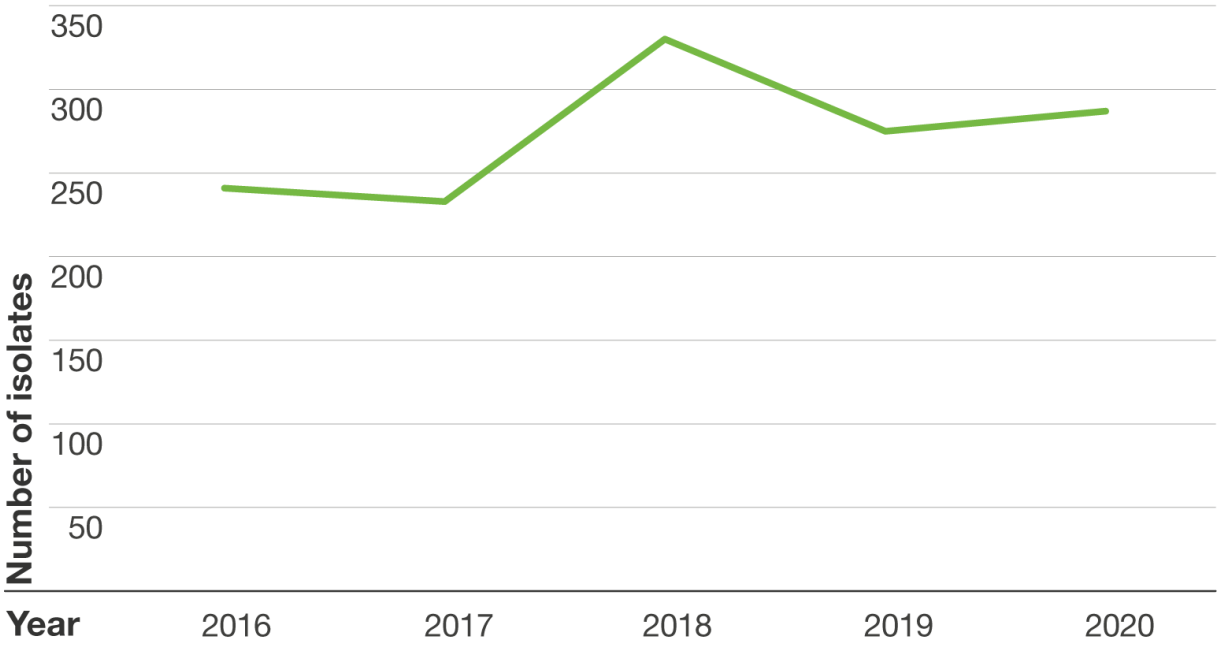
Animal

Salmonella isolates were tested for susceptibility by inference of AMR phenotype from WGS data in the same way as for human isolates. No information on prior antibiotic treatment is available for *Salmonella* isolates identified from animal samples.

The submission of samples is affected by the willingness of an animal keeper to pay the costs of laboratory testing to inform treatment, in addition to the clinical presentation in the affected animal(s). A number of *Salmonella* spp. are adapted to particular animal host species and are only found rarely in others. Generally, *Salmonella* infection in animals can result in clinical syndromes suggestive of bacteraemia and systemic illness and, in these cases, antibiotic therapy would sometimes be part of the treatment regimen instituted by an attending veterinarian. Vaccines against some serotypes of *Salmonella* spp. are available for some animal species, and are used to a greater or lesser extent depending on a number of factors including assessed risk of infection in the particular group of animals.

In 2020 there were 287 reports of *Salmonella* in animals, compared to 275 in 2019 (**Figure 30**).

Figure 30: Number of laboratory confirmed *Salmonella* isolates from animals in Scotland, 2016 to 2020.



[Data source: Electronic Communication of Surveillance in Scotland (ECOSS)]

The majority of reports were from cattle (55.4%), pigs (19.4%) and sheep (9.0%). The remaining reports were from a variety of animals including dogs, cats, reptiles, tropical fish, birds and wild animals. Isolates from companion animals accounted for 7.6%.

Susceptibility of animal non-typhoidal *Salmonella*

In 2020, 79.1% (n=227) of *Salmonella* reported from animals were fully susceptible as determined by phenotypic inference from WGS. This compares to 77.7% of isolates in 2019, 64.8% of isolates in 2018 and 72.1% of isolates in 2017.

Non-susceptibility was 19.2% for tetracycline, 18.8% for sulphamethoxazole, 18.1% for ampicillin, 1.7% for ciprofloxacin and 19.5% for streptomycin (see **Appendix**).

Salmonella Antimicrobial Resistance Determination in the Genomic Era

The power of using WGS for detailed molecular epidemiology is now being further enhanced by using a genotypic approach for AMR surveillance. Increased knowledge on the prevalence of individual AMR genes in human, animal and environmental sources will be important in the evaluation of the impact of resistance on One Health.

Extended spectrum β-lactamase (ESBL) genes were detected in two human isolates (0.6%), with one CTX-M-1 in an isolate of *S.* Infantis and one CTX-M-55 in an isolate of *S.* Typhimurium (associated with travel to South America). No ESBL genes were detected in isolates of animal origin.

The predominant β-lactamase genes detected in both human and animal isolates were the TEM β-lactamases and the CARB-2 β-lactamase. The TEM genes were identified in a diverse group of serotypes including Derby, Enteritidis, Indiana, Infantis, Kentucky, Newport, Typhimurium, and the monophasic variant of Typhimurium, and were commonly associated with the carriage of strA/strB, tetA and sul-2. The CARB-2 gene was exclusively associated with a clonal group of *S.* Typhimurium strains which have been identified as most likely belonging to the historically important “DT104 complex”, and also carried the integron-associated classical combination aadA (Streptomycin), floR (Chloramphenicol), tetG (tetracycline) and sul-1 (sulphonamides).

Apart from the streptomycin resistance genes discussed above, genes encoding resistance to other aminoglycosides (gentamicin and kanamycin) were rare in both human and animal isolates (<2%).

Fluoroquinolone resistance determinants were more commonly found in human isolates (23.4 %) than in animal isolates (1.7%). Genetic signatures for higher level ciprofloxacin resistance (MIC > 0.5mg/L) were identified in 2.3% of human isolates but not in animal isolates. Plasmid mediated qnr (quinolone resistance) resistance genes were identified in 8.8% of human isolates. Four (13.3%) of 30 human qnr containing isolates were from cases that reported foreign travel. This compares with a previous Scottish study from 2008 in which 52.9% of the isolates (n=18) identified as containing qnr genes were from cases where foreign travel had been reported.[37]

No mobile colistin resistance genes were detected in human or animal isolates in 2020.

No carbapenem resistance genes were detected in human or animal isolates in 2020.

Antimicrobial resistance in animals

AMR in veterinary clinical isolates from livestock (SRUC)

This is the fifth year that data on resistance in veterinary clinical isolates from Scotland have been reported in the SONAAR report. Knowledge on AMR in bacterial isolates from animals with disease is necessary to understand more fully the epidemiology of AMR in a One Health context.

For 2020, data are only presented from livestock species. These data derive from clinical specimens submitted to the farm animal diagnostic services offered by Scotland's Rural College (SRUC) Veterinary Services. The data from veterinary clinical isolates are subject to a number of important biases. Unlike the clinical samples in humans in Scotland, the samples are tested on a 'charged for' basis to inform private veterinary treatment of diseased animals. There is a cost to the animal keeper that affects the submission of samples to these services.

In addition, the primary purpose of screening for AMR is to inform veterinary treatment and isolates from animals are tested against a panel of antimicrobials relevant for that purpose at, where they exist, species-relevant clinical breakpoints. Interpretation of these data in terms of their relevance to public health is challenging beyond the notion of evidence of impact of a selection pressure existing in another compartment of the ecosystem that humans share closely with animals. The micro-organisms included are selected based both on their prevalence among all submissions, i.e. their importance as causes of animal morbidity, as well as, in some cases, their similarity to micro-organisms that cause morbidity in humans.

Staphylococcus spp.

Staphylococcus spp. are common commensal organisms that can act as important opportunist pathogens of humans and other animals.

The sensitivity patterns for *Staphylococcus aureus (S. aureus)* for 2016 to 2020 are shown in the **Appendix**. In 2020, meticillin resistance was not detected in *S. aureus* from livestock.

Streptococcus spp.

Streptococcus spp. can be important pathogens or opportunist colonisers of livestock species, with the potential to cause severe disease of the skin, respiratory tract, body cavities, wounds and urinary tract. Some species, including *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, and *Streptococcus suis*, are also recognised in human infections. The non-susceptibility patterns for selected *Streptococcus* spp. for 2016 to 2020 are shown in the **Appendix**.

Pasteurellaceae

Pasteurellaceae are important causes of potentially severe respiratory and soft tissue infections in livestock animals. In livestock animals, high levels of morbidity and mortality can result with consequential significant economic losses. Important bacterial species included in this report are *Pasteurella multocida* (cattle, sheep, pigs), *Mannheimia haemolytica* (cattle and sheep), *Bibersteinia trehalosi* (cattle and sheep) and *Actinobacillus pleuropneumoniae* (pigs). The non-susceptibility patterns for the selected *Pasteurellaceae* for 2016 to 2020 from livestock animals are shown in the **Appendix**.

Escherichia coli

E. coli are a major constituent of the normal faecal flora of humans and warm-blooded animals. However, some strains can cause intestinal and extraintestinal disease. The non-susceptibility patterns for the selected *E. coli* for 2016 to 2020 from livestock animals are shown in the **Appendix**.

Klebsiella pneumoniae

K. pneumoniae is a cause of significant economic loss to the livestock industry and is potentially zoonotic. The non-susceptibility patterns for *K. pneumoniae* for 2019 and 2020 are shown in the **Appendix**.

Extended-spectrum beta-lactamase producing *Enterobacterales*

ESBL were identified in *Enterobacterales* from one diagnostic isolate in 2020 - *K. pneumoniae* from a cow's milk. This was further identified as *bla*$_{\text{CTX-M-15}}$ harbouring *K. pneumoniae* ST187.

Carbapenemases

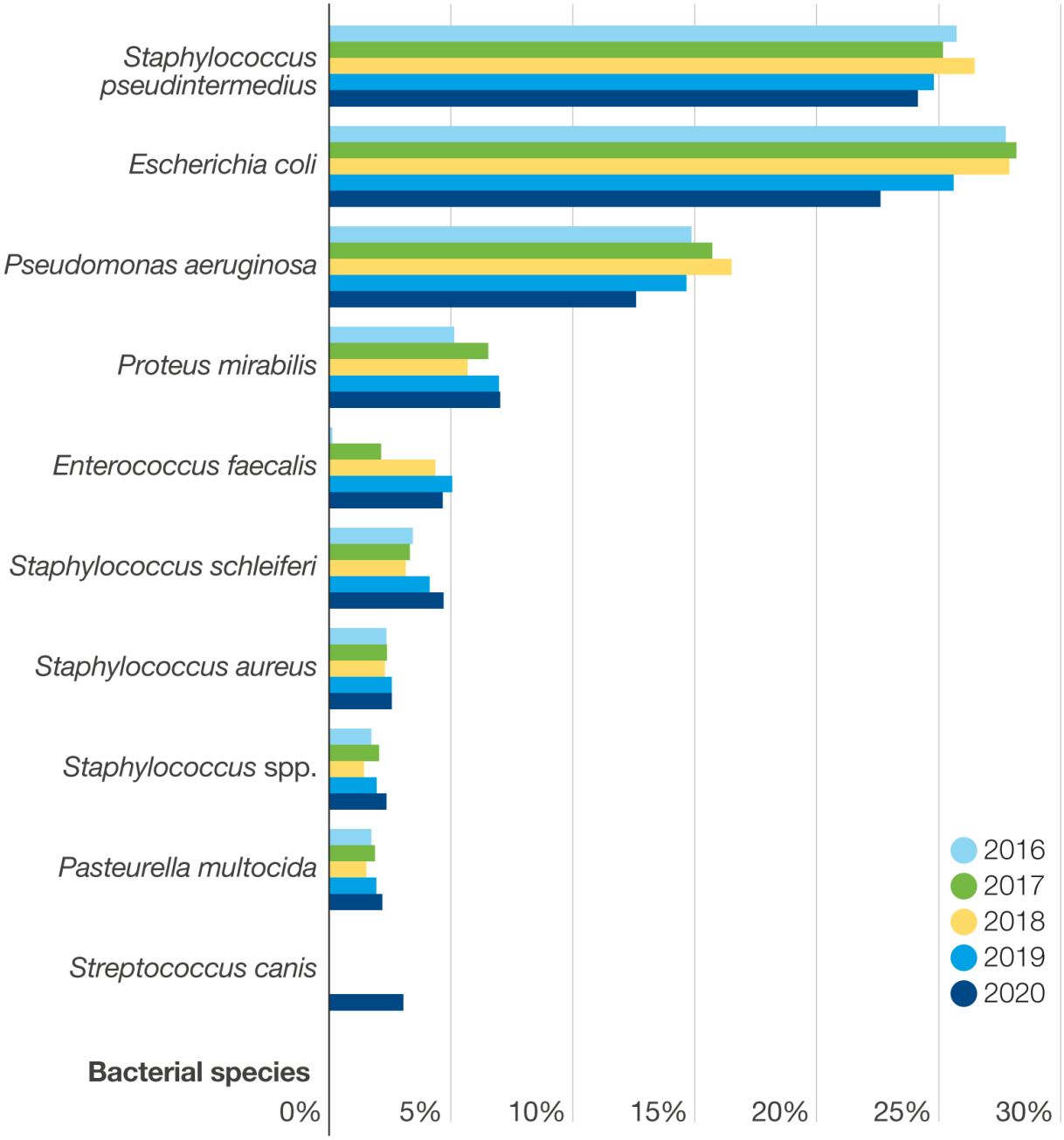
Carbapenemases were not detected in any animal isolates.

AMR in companion animals (SAVSNET)

Data on AMR in small companion animals were available from Scottish veterinary practices that contribute to SAVSNET for 2019 and 2020. A total of 4,907 and 4,780 bacterial isolates were reported in 2019 and 2020, respectively. In 2019, 86.5% (n=4,247) of the total 4,907 isolates were from dogs and 13.5% (n=660) from cats. In 2020, 86.1% (n=4,117) of the total 4,780 isolates were from dogs and 13.9% (n=663) from cats.

The distribution of bacterial species isolated is described in **Figure 31**. *Staphylococcus pseudintermedius* (*S. pseudintermedius*) (n=1,154, 24.1%) and *E. coli* (n=1,081, 22.6%) were the most frequently isolated bacteria in 2020.

Figure 31: The 10 most common bacterial isolates in companion animals during 2020 as percentage of the total isolates per year, 2016 to 2020.



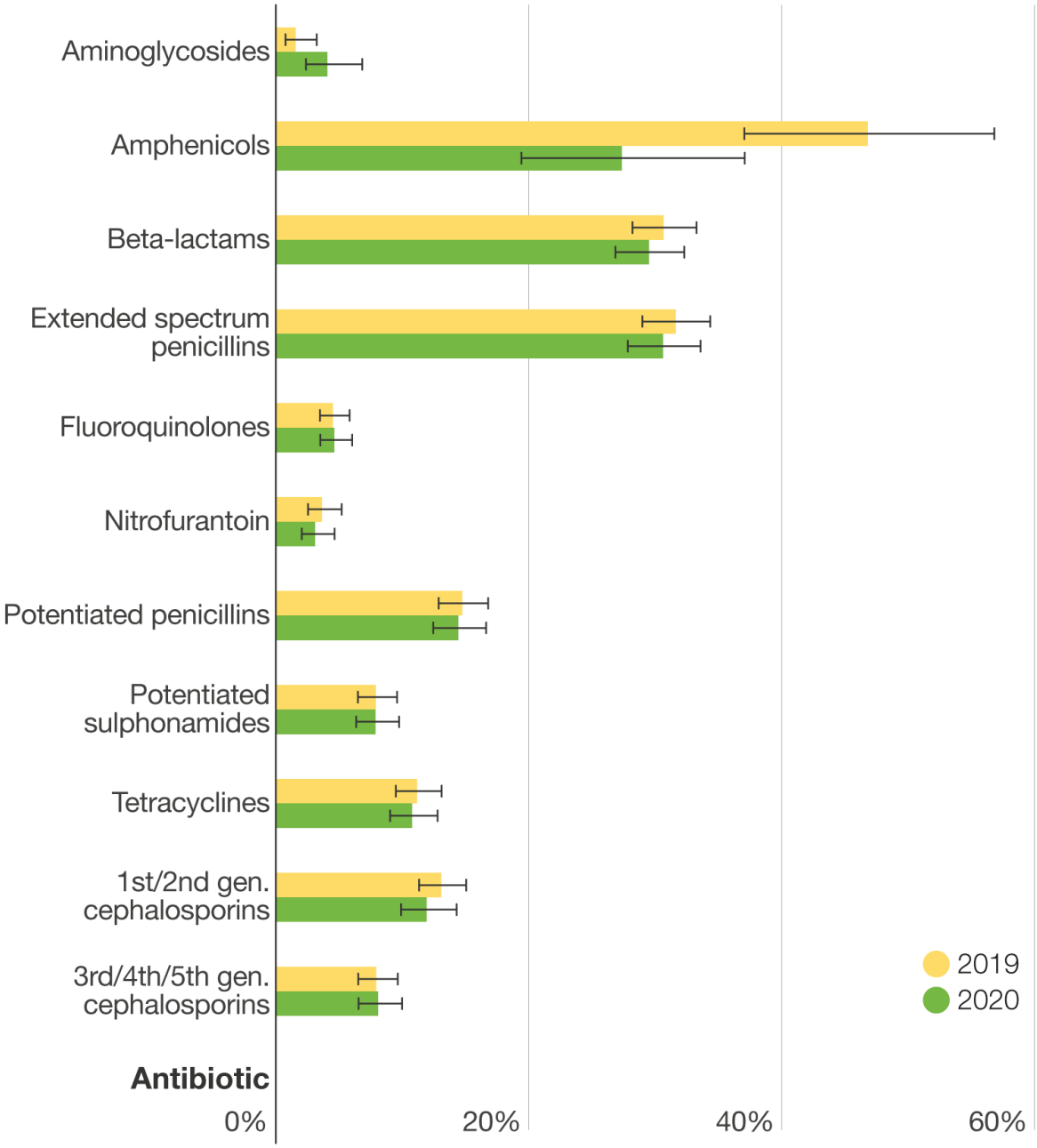
Note: There were a further 85 bacterial species accounting for 672 isolates (14.1%), each with a prevalence of >1.5%. [Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

The following graphs present the percentage of isolates of *E. coli*, *S. pseudintermedius*, *S. aureus* and *Staphylococcus schleiferi* (*S. schleiferi*) from all companion animals non-susceptible to pathogen-appropriate antimicrobial classes for 2019 and 2020.

AMR in *Escherichia coli* from companion animals

There was a total of 1,257 (80.3% from dogs) and 1,081 (80.4% from dogs) isolates of *E. coli* reported for 2019 and 2020, respectively. The percentage of isolates that were non-susceptible to selected antimicrobial classes in each year is shown in **Figure 32**.

Figure 32: Percentage of *E. coli* cat and dog isolates non-susceptible to antimicrobial classes, 2019 to 2020.

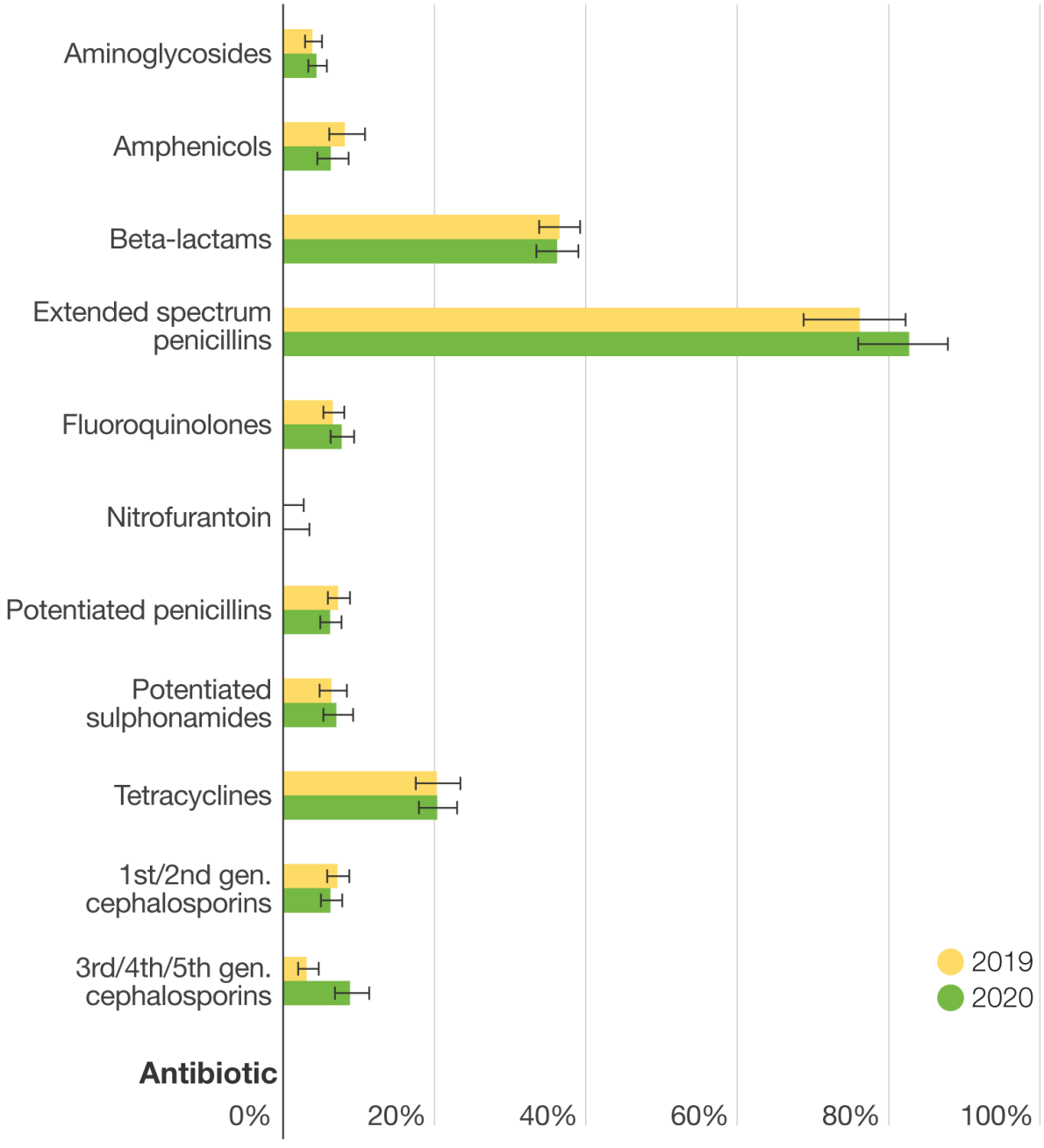


[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

AMR in *S. pseudintermedius* from companion animals

There was a total of 1,217 (98% from dogs) and 1,154 (98.4% from dogs) isolates of *S. pseudintermedius* reported for 2019 and 2020, respectively. The percentage of isolates that were non-susceptible to selected antimicrobial classes in each year is shown in **Figure 33**.

Figure 33: Percentage of *S. pseudintermedius* cat and dog isolates non-susceptible to antimicrobial classes, 2019 to 2020.

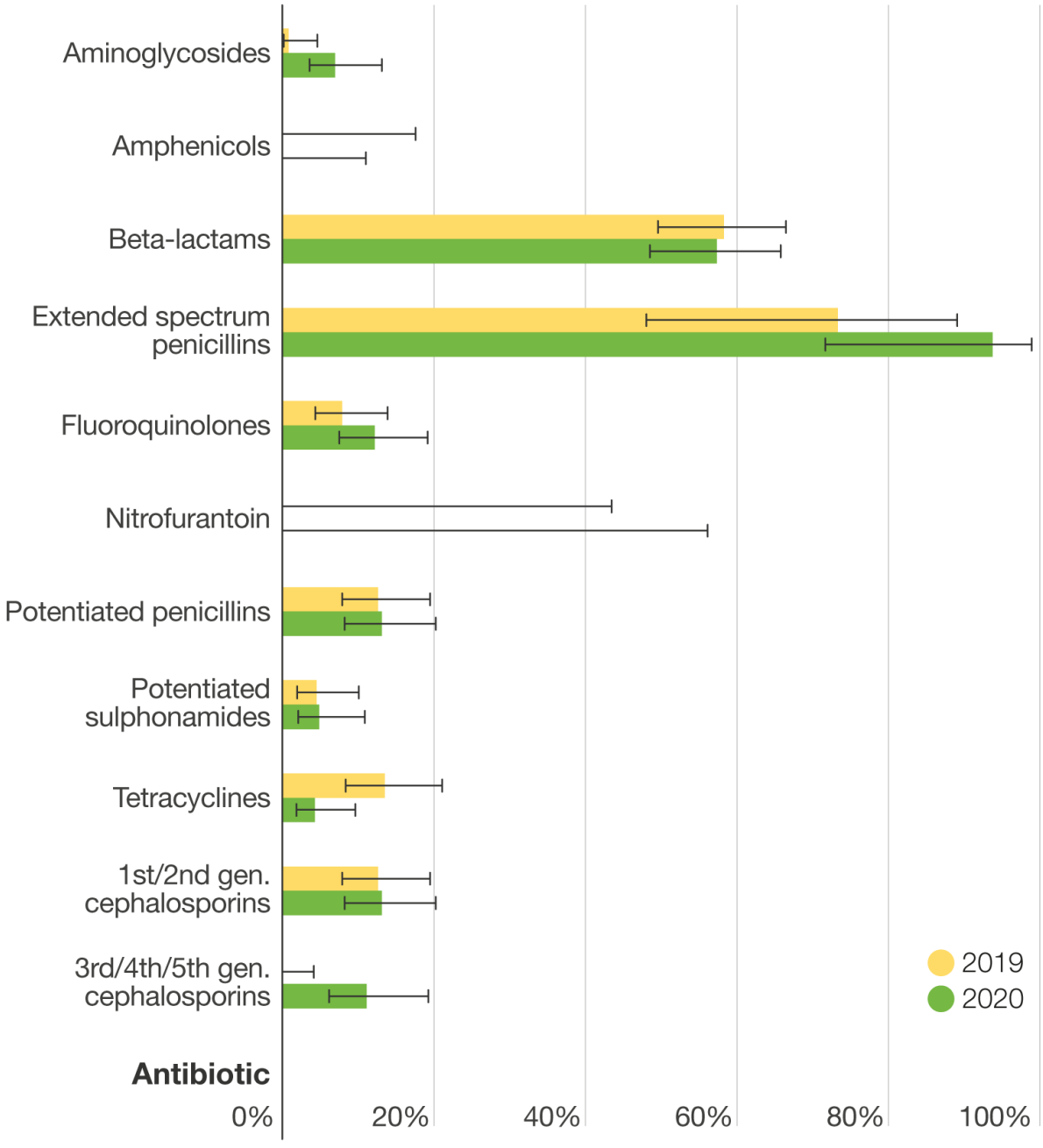


[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

AMR in *S. aureus* from companion animals

There was a total of 127 (68.5% from dogs) and 123 (65.9% from dogs) isolates of *S. aureus* reported for 2019 and 2020, respectively. The percentage of isolates that were non-susceptible to selected antimicrobial classes in each year is shown in **Figure 34**.

Figure 34: Percentage of *S. aureus* cat and dog isolates non-susceptible to antimicrobial classes, 2019 to 2020.

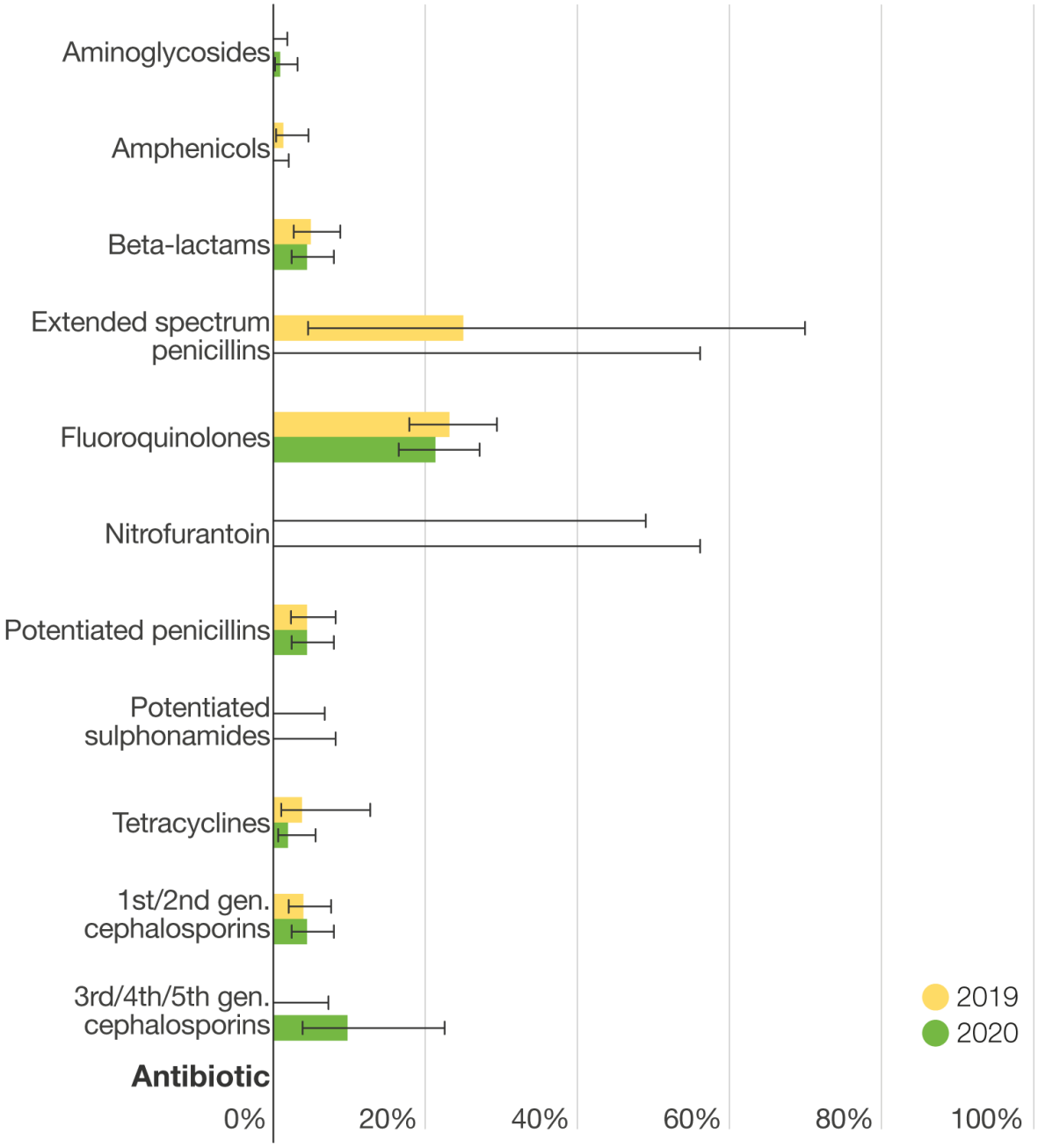


[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

AMR in *S. schleiferi* from companion animals

There was a total of 203 (98.5% from dogs) and 225 (99.1% from dogs) isolates of *S. schleiferi* reported for 2019 and 2020, respectively. The percentage of isolates that were non-susceptible to selected antimicrobial classes in each year is shown in **Figure 35**.

Figure 35: Percentage of *S. schleiferi* cat and dog isolates non-susceptible to antimicrobial classes, 2019 to 2020.

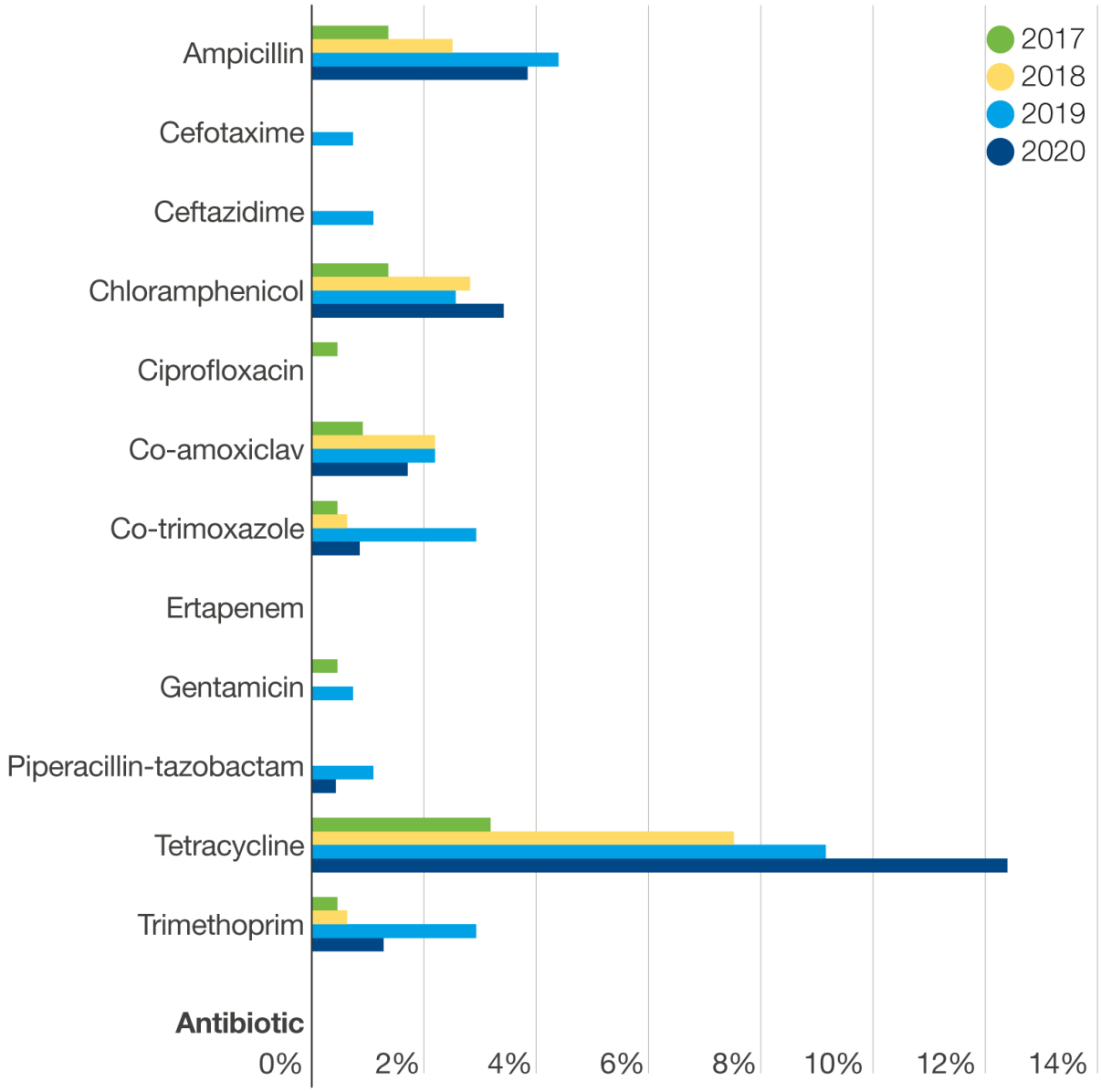


[Data source: Small Animal Veterinary Surveillance Network (SAVSNET)]

AMR in *E. coli* isolates from healthy livestock

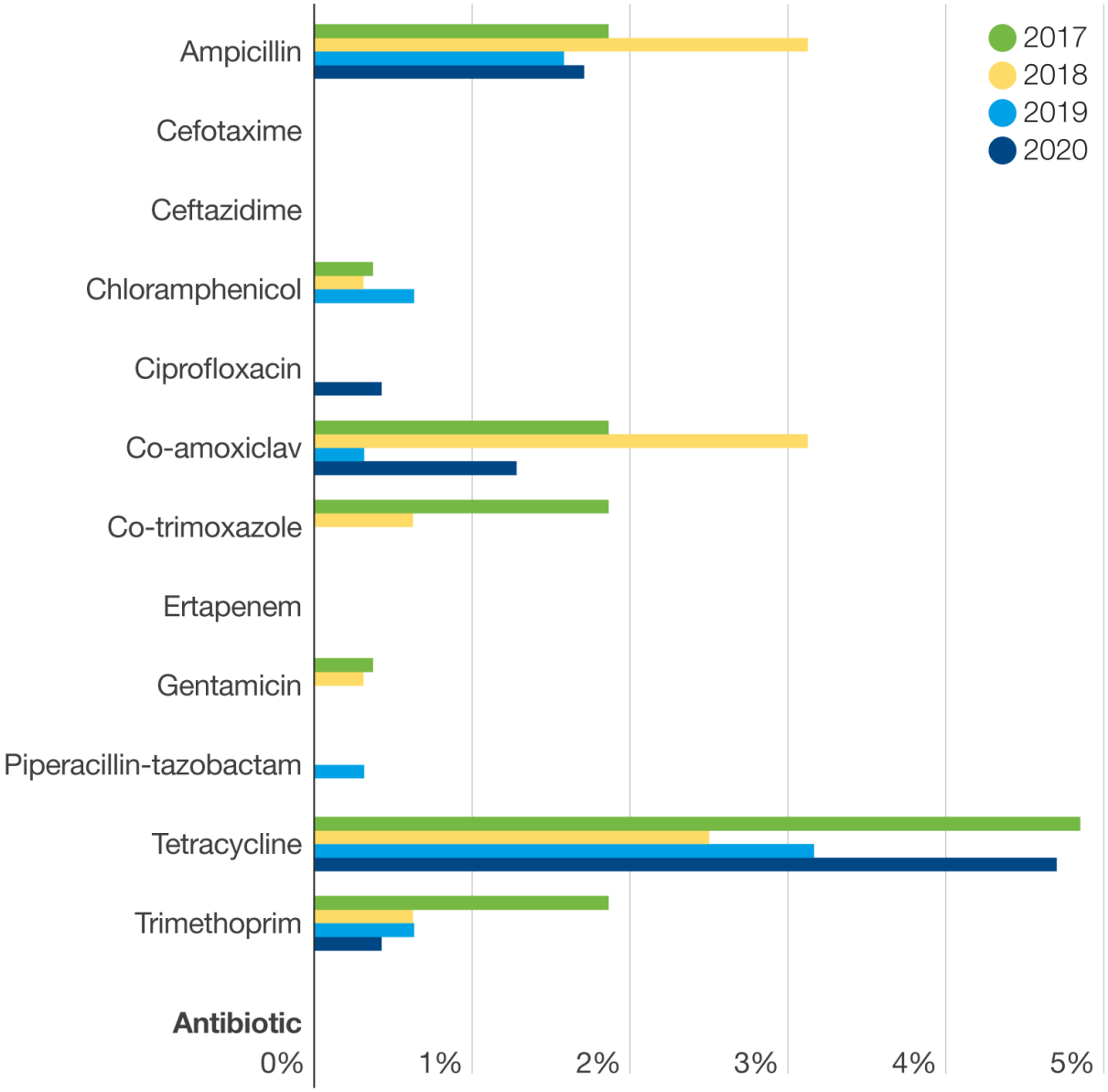
In addition to diagnostic isolates, *E. coli* collected from enteric samples of healthy animals are tested as a measure of the background resistance in livestock entering the food chain. Since 2017, an ongoing project in collaboration with Food Standards Scotland monitors the prevalence of resistance in *E. coli* cultured from cattle, sheep, pigs and poultry presenting at abattoirs in Scotland for slaughter for human consumption. The antimicrobials that the *E. coli* isolates from healthy animals were tested for susceptibility against were selected specifically for their relevance for human treatment, rather than veterinary practice. Results for each of the four years for each livestock host are presented in **Figure 36**, **Figure 37**, **Figure 38** and **Figure 39**. Continued monitoring is important for comparison over several years. In 2020, as was reported in previous years, proportions of non-susceptibility in isolates from pigs and poultry sampled were greater than in those from cattle and sheep, for which numbers of non-susceptible isolates were very low (see **Appendix**). Amongst high priority critically important antimicrobials, non-susceptibility was not detected to ertapenem. Non-susceptibility to third generation cephalosporins remained low and was only detected from poultry (3 isolates) and pigs (a single isolate). In 2020, ciprofloxacin (fluoroquinolone) non-susceptibility was detected from a single isolate in sheep and a single isolate in pigs, but in 15.5% of poultry isolates, which is an increase (674.2%, $p<0.001$) from 2% in 2019. As in previous years, there was again a notable proportion of isolates from poultry non-susceptible to gentamicin and isolates from pigs non-susceptible to chloramphenicol.

Figure 36: Percentage of *E. coli* isolates that were non-susceptible to selected antimicrobials in healthy cattle in Scotland, 2017 to 2020, by antimicrobial.



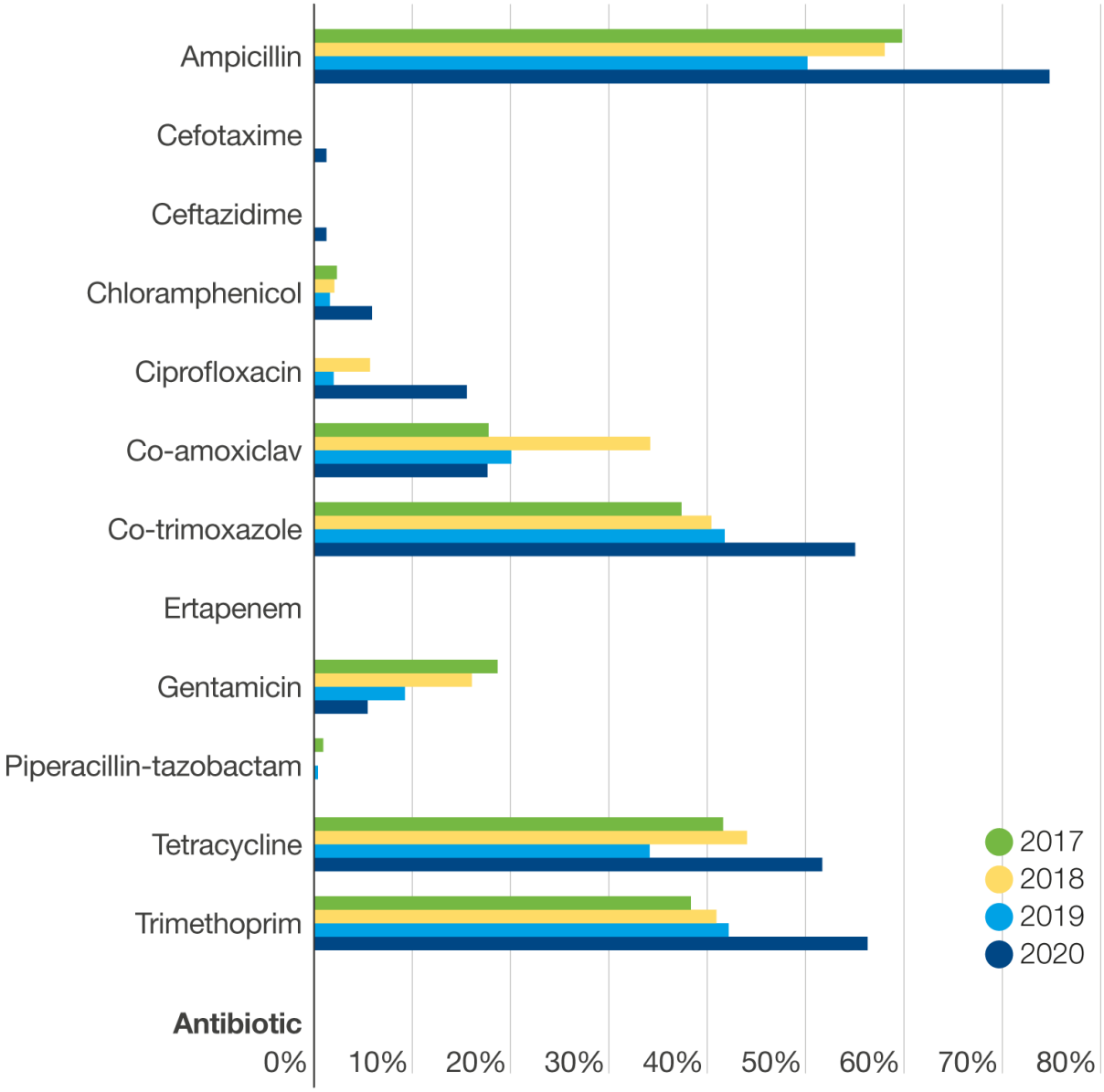
[Data source: Scotland's Rural Collage (SRUC)]

Figure 37: Percentage of *E. coli* isolates that were non-susceptible to selected antimicrobials in healthy sheep in Scotland, 2017 to 2020, by antimicrobial.



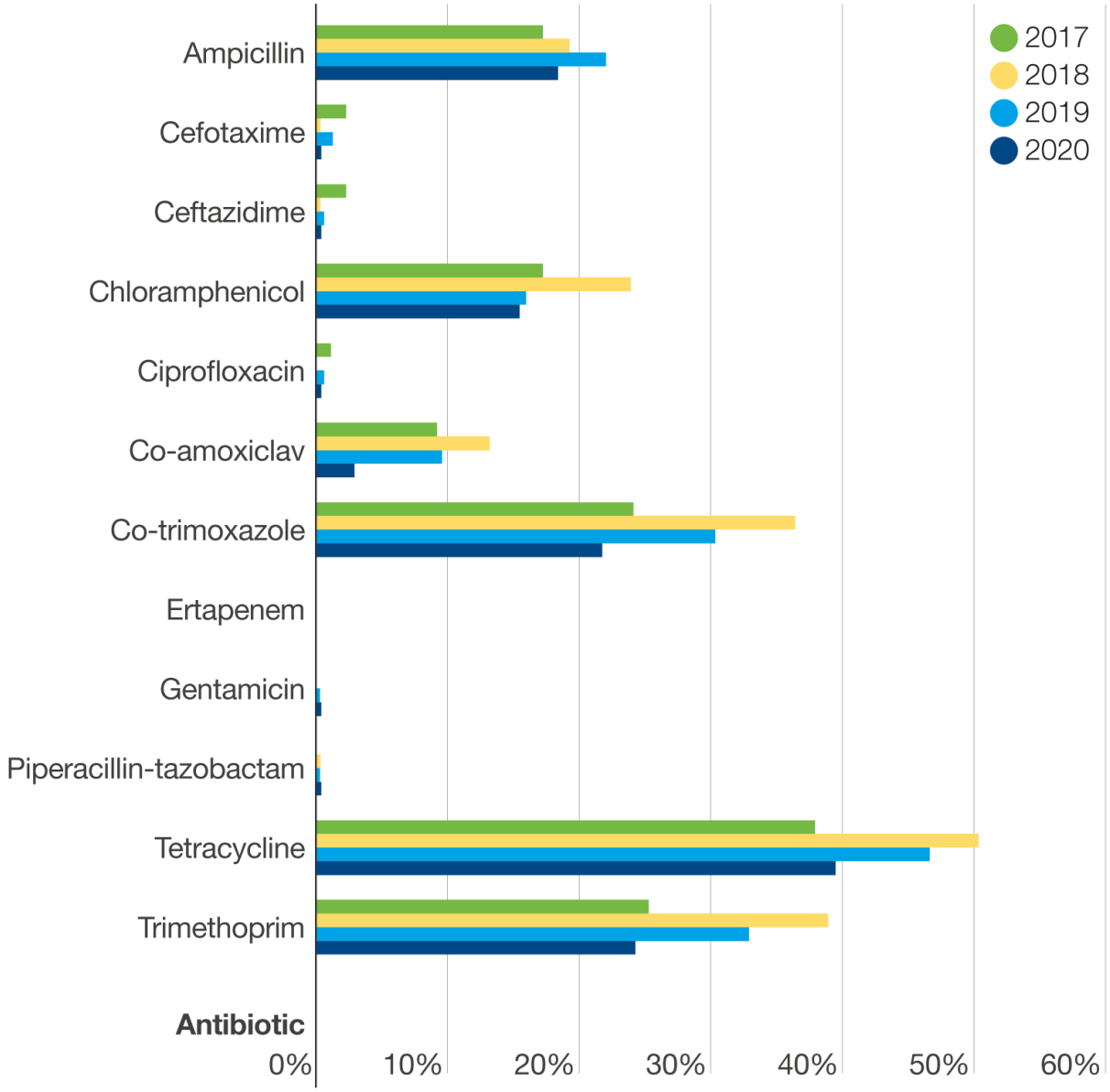
[Data source: Scotland's Rural Collage (SRUC)]

Figure 38: Percentage of *E. coli* isolates that were non-susceptible to selected antimicrobials in healthy poultry in Scotland, 2017 to 2020, by antimicrobial.



[Data source: Scotland's Rural Collage (SRUC)]

Figure 39: Percentage of *E. coli* isolates that were non-susceptible to selected antimicrobials in healthy pigs in Scotland, 2017 to 2020, by antimicrobial.

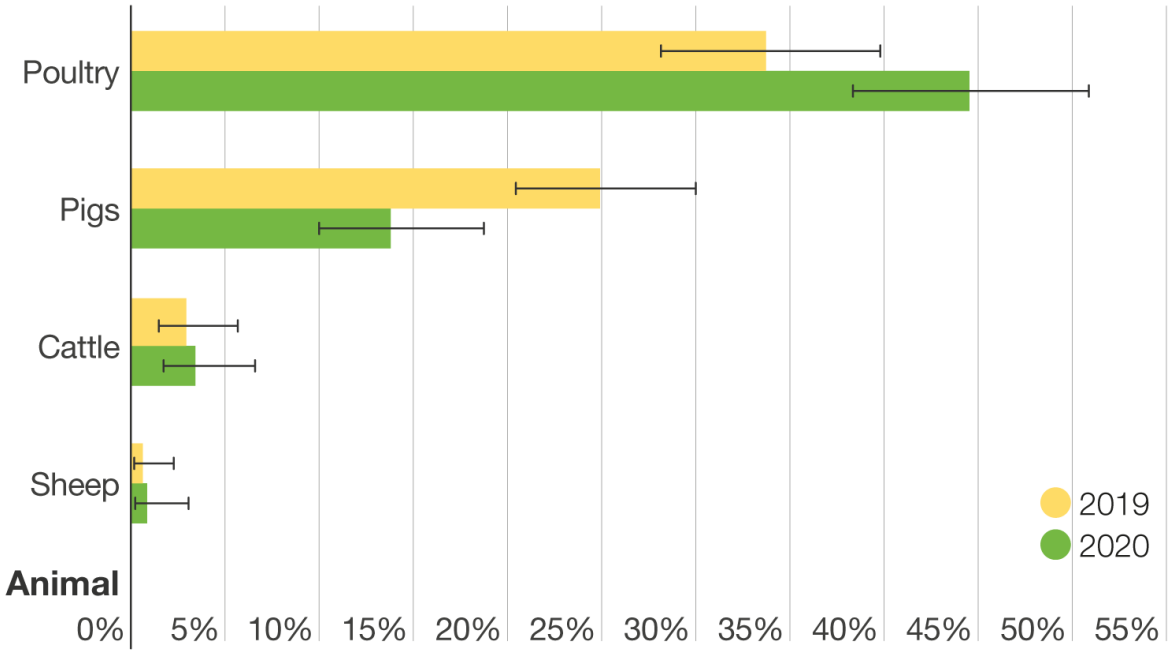


[Data source: Scotland's Rural Collage (SRUC)]

Multi Drug Resistance (MDR) in *E. coli* isolates from healthy livestock

For the first time in this report we present a year-on-year comparison between 2020 and 2019 data in terms of the percentage of isolates deemed to be multi drug resistant (MDR) which is defined as acquired resistance to three or more antimicrobial classes. These are presented in the following figure, **Figure 40**, by animal species. Based on two years' reporting, these appear stable in cattle and sheep but less so in poultry and pigs. Although derived from samples collected from somewhat different stages of production in the different animal species, and processed using different microbiological methods, data from the periodic European Union Summary Report on Antimicrobial Resistance in zoonotic and indicator bacteria from humans, animals and food may be a relevant basis for cautious comparison. Our 2020 data sit towards the lower end of European ranges for cattle and pigs and towards the median for poultry.

Figure 40: Percentage of *E. coli* isolates classed as MDR in healthy livestock in Scotland, with 95% confidence intervals, 2019 to 2020.



[Data source: Scotland's Rural Collage (SRUC)]

Animal AMR Key Points

- **AMR is a feature of bacterial pathogens affecting all domestic animal species.**
- **Antimicrobial susceptibility testing (AST) to support veterinary treatment comes primarily from private laboratories but is not currently part of a formal surveillance system.**
- **Monitoring of AMR in animals is a vital component of understanding and mitigation of AMR across the entire ecosystem.**
- **Responsible Use of Medicines in Agriculture Alliance (RUMA) Targets Task Force 2: One Year On and Veterinary Antimicrobial Resistance and Sales Surveillance Report of 2020 demonstrate serious commitment to antimicrobial stewardship in UK livestock.**

Monitoring AMR further along the food chain

Antimicrobial Resistance in Foodborne Pathogens and Generic *E. coli* Isolated from Mince Beef across Scotland.

Food Standards Scotland (FSS) commissioned SRUC and partners to conduct a survey investigating the microbial quality of beef mince on retail in Scotland. In 2019, approximately 1,000 samples of beef mince were collected at retail across Scotland to determine the overall presence of three significant microbiological pathogens and two process hygiene indicators.

All successfully isolated pathogens and 100 generic *E. coli* underwent antimicrobial sensitivity testing[1] (AST; using minimum inhibitory concentration for colistin and disc diffusion technique for all other antimicrobials) and WGS to check for phenotypic and genotypic AMR respectively.

The majority of isolates were susceptible to all the antibiotics that they were tested against. None of the isolates were resistant to any of the critically important antimicrobials that were tested for by disc diffusion.

The full report was published on the Food Standards Scotland website in June 2021.

Minimising the spread of AMR through the environment

Minimising the spread of AMR through the environment remains a UK priority and the UK's five-year NAP sets out the ambitions in this area.[1]

The role of the environment as a transmission route for many bacterial pathogens has long been recognised, often associated with insufficient sewage infrastructure, faecal contamination of water or organic fertilisers). More recently, the understanding has developed that many of the resistance genes that we find in pathogens today originate from bacteria normally thriving in the environment. Hence, the environment acts as a dispersal route and reservoir of resistant pathogens, and also as an arena for the evolution of resistance.[38-40]

The NAP states that there should be increased activity to identify and assess sources, pathways and exposure risks including their interdependencies that create the opportunity to impact on the presence and persistence of AMR in the environment. The action plan also advocates the evaluation of existing regulations to evaluate whether they can be applied, and if not amended, to encompass monitoring of AMR in the environment. Engagement at a global level also remains a key priority.

ARHAI Scotland has engaged with environment and veterinary agencies and academia to scope out collaborative areas of work. Initial work with the Scottish Environment Protection Agency (SEPA), SRUC and Edinburgh Napier University has centred around cefotaxime resistant *E. coli* in human bacteraemia isolates, healthy animal isolates and bathing water isolates. Cefotaxime was chosen as it is widely used to treat human infection and is currently routinely tested against human, healthy animal and bathing water isolates.

SEPA has tested for and detected cefotaxime resistant *E. coli* in water samples collected from Scotland's designated bathing water sites during the bathing water season (June to mid-September) in 2018, 2019, and 2021. SEPA has also tested cefotaxime resistant *E. coli* isolates for resistance to a range of other antibiotics and detected resistance.

SEPA has produced a web-based data visualisation tool for the sharing, assessment, and presentation of its bathing waters AMR surveillance data and this can be accessed by clicking the following link: https://informatics.sepa.org.uk/AMRmonitoring.

ARHAI Scotland will continue to work closely with SEPA to monitor and better understand the pattern and potential exposure and associated health risks of antibiotic resistance in *E. coli* in the environment.

List of Abbreviations and Acronyms

AMEG	Antimicrobial Advice Ad Hoc Expert Group
AMR	Antimicrobial Resistance
AMR-EWS	Antimicrobial Resistance Early Warning System
AMRHAI	Antimicrobial Resistance and Healthcare Associated Infections
AMT	Antimicrobial Management Teams
AMU	Antimicrobial Use
AMS	Antimicrobial Stewardship
ARHAI Scotland	Antimicrobial Resistance and Healthcare Associated Infection Scotland
AST	Antimicrobial Susceptibility Testing
BSAC	British Society for Antimicrobial Chemotherapy
BSI	Bloodstream Infection
CAUTI	Catheter Associated Urinary Tract Infection
CLSI	Clinical and Laboratory Standards Institute
COVID-19	Coronavirus disease 2019
CPE	Carbapenemase-producing Enterobacterales
CPO	Carbapenemase-producing Organism
DDDs	Defined Daily Doses
ECB	*Escherichia coli* bacteraemia
ECDC	European Centre for Disease Prevention and Control

ECOSS	Electronic Communication of Surveillance in Scotland
EMA	European Medicines Agency
ESBL	Extended spectrum beta-lactamases
EWS	Early Warning System
EU	European Union
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FSS	Food Standards Scotland
GP	General Practitioner
HCAI	Healthcare Associated Infection
HMUD	Hospital Medicines Utilisation Database
HP-CIA	High Priority Critically Important Antibiotics
HPS	Health Protection Scotland
HPT	Health Protection Team
IPCT	Infection Prevention and Control Team
ISD	Information Services Division
IV	Intravenous
MDR	Multi-Drug Resistant
MRSA	Meticillin Resistant *Staphylococcus aureus*
NAP	National Action Plan
NDM	New Delhi Metallo-beta-lactamases
NHS	National Health Service

NICE	National Institute for Health and Care Excellence
NIPCM	National Infection Prevention Control Manual
NRS	National Records of Scotland
OBD	Occupied Bed Days
OXA	Oxacillinase
PHE	Public Health England
PIS	Prescribing Information System
RUMA	Responsible Use of Medicines in Agriculture Alliance
SAC	Scottish Agricultural College
SAPG	Scottish Antimicrobial Prescribing Group
SARIS	Surveillance of Antimicrobial Resistance in Scotland
SAVSNET	Small Animal Veterinary Surveillance Network
SEAG	Scottish Environmental AMR Group PCM
SEPA	Scottish Environmental Protection Agency
SMA	Scottish Microbiology Association
SMiRL	Scottish Microbiology Reference Laboratory
SMVN	Scottish Microbiology and Virology Network
SOHNAAP	Scottish One Health National AMR Action Plan Group
SONAAR	Scottish One Health Antimicrobial Use and Antimicrobial Resistance
SRUC	Scotland’s Rural College
SUTIN	Scottish UTI Network

UK	United Kingdom
UTI	Urinary Tract Infection
VARSS	Veterinary Antimicrobial Resistance and Sales Surveillance
VRE	Vancomycin-resistant enterococci
WGS	Whole Genome Sequencing
WHO	World Health Organisation

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Contact

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Health Protection Scotland website: http://www.hps.scot.nhs.uk

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- Scottish Antimicrobial Prescribing Group (SAPG)
- Scottish Microbiology and Virology Network (SMVN)
- Scottish Environment Protection Agency (SEPA)
- Scotland's Rural College (SRUC) which includes Scottish Agricultural College (SAC) Veterinary Services and Capital Diagnostics in Scotland
- Scottish Animal Health and Antimicrobial Resistance (SAHAMR)
- Scottish Veterinary Antimicrobial Stewardship (SVAS) Groups
- Small Animal Veterinary Surveillance Network (SAVSNET)
- Food Standards Scotland

Appendices

Appendix 1 – Background information

Revisions to the surveillance

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Implementation of new Biomerieux® Vitek AST cards within laboratories	2020	Human AMR	Implementation of new Biomerieux® Vitek AST cards in late 2018 that test amoxicillin in combination with a fixed clavulanic acid concentration of 2 mg/L as per EUCAST recommendations. Roll out across NHS boards was variable due to laboratories depleting existing stock of older cards. This change was associated with an increase in co-amoxiclav non-susceptibility in 2019
Changes in healthy animal breakpoints	2020	AMR in animals	Changes in health animal breakpoints for ampicillin, co-trimoxazole, tetracycline and trimethoprim. These have not been retrospectively applied to historical data therefore care is needed in interpreting changes between 2018 and 2019.
Implementation of v_9.0 EUCAST breakpoints	2020	Human AMR	Reduction in ciprofloxacin MIC for *Acinetobacter* species from ≤1 mg/L to ≤ 0.06 mg/L and creation of an intermediate (I) category. Scottish Biomerieux® Vitek AST

			cards only read MIC as low as 0.25 calling range. Introduction of Areas of Technical Uncertainty (ATU) for *Enterobacterales* against piperacillin-tazobactam and ciprofloxacin. Although in the intermediate (I) category, results for these antibiotics may be downgraded to resistant (R) as per EUCAST guidance.
Temocillin breakpoints (*Enterobacterales*)	2020	Human AMR	No EUCAST breakpoint available. Initially all Biomerieux® Viteks used BSAC legacy UTI breakpoint of 16. GGC moved to systemic breakpoint of 8 in ~2015. Other boards moved variably up until end 2017. Glasgow and some others retained an I category (MIC 16) up until Oct 2019 when all moved to S<8 and R>8.
Change to episode based reporting for antimicrobial susceptibility data	2020		Data processing antimicrobial susceptibility data: For bacteraemias and UTIs, only the first isolate (of one specific organism per rolling 14-day period for blood and per rolling 30 day period for urine) is reported as a case. This is equivalent to one episode of infection. The most complete or most resistant AST result during each episode is reported for each case. Where more than one organism was present in a sample deduplication was carried out separately for each organism.

Appendix 2 – Metadata

Publication title

Scottish One Health Antimicrobial Use and Antimicrobial Resistance report, 2020 (SONAAR report, 2020)

Description

This annual report provides data relating to antimicrobial use and antimicrobial resistance in Scotland during 2020.

Theme

Health and Care (ARHAI SCOTLAND, NHS National Services Scotland and Public Health Scotland).

Topic

Antimicrobial use and resistance in humans and animals.

Format

Online resource (PDF).

Data source(s)

Antibiotic Use in Humans

Antibiotic use in primary care: Prescribing Information System (PIS), Public Health Scotland (PHS).

Population denominator data: Mid-year population projections for Scotland:

National Records of Scotland (NRS) population estimates.

Antibiotic use in secondary care: Hospital Medicines Utilisation Database (HMUD), PHS.

Healthcare associated denominator: Total occupied bed days (OBD), Sum of OBDs for all hospitals in numerator: Information Services Division ISD(S)1, PHS.

Antibiotic Use in Animals

Antibiotic use in companion animals: Small Animal Veterinary Surveillance Network (SAVSNET).

Human Antimicrobial Resistance

Bacteraemia: Electronic Communication of Surveillance in Scotland (ECOSS).

Urinary tract infection: ECOSS.

Carbapenemase Producing Organisms (CPOs): ECOSS and the Scottish AMR Satellite Laboratory (SMiRL, Glasgow).

Exceptional phenotypes: ECOSS.

***Salmonella* in humans**: ECOSS and Scottish Microbiology Reference Laboratory (SMiRL) via PHS.

Animal Antimicrobial Resistance

Animal *Salmonella*: ECOSS and SMiRL via PHS.

AMR in companion animal isolates: SAVSNET.

AMR in livestock animal clinical isolates: Scotland's Rural College (SRUC) Veterinary Services.

***Staphylococcus aureus* animal isolates antimicrobial susceptibility data**:

Meticillin resistant *Staphylococcus aureus* (MRSA) reference laboratory via SRUC.

AMR in healthy animals (abattoir): SRUC Veterinary Services.

Date that data are acquired

Antibiotic Use in Humans

Antibiotic use in primary care:

Patient-based analysis: 13/07/2021

Urinary tract infections (UTI) analysis: 19/07/2021

Primary Care (PC) Trend data: 07/09/2021

PC Duration of course analysis: 07/09/2021

PC Variation analysis: 07/09/2021

PC Antifungal analysis: 08/09/2021

Population denominator data: Mid-year population projections for Scotland: 19/07/2021

Antibiotic use in secondary care:

Secondary Care (SC) Trend analysis: 06/09/2021

SC Antifungal analysis: 08/09/2021

Healthcare denominator data: Total occupied bed days, Sum of OBDs for all hospitals in numerator: 14/07/2021

Antibiotic Use in Companion Animals

Antibiotic use in companion animals: 12/10/2021

Human Antimicrobial Resistance

Bacteraemia: 03/08/2021

Population denominator data: Mid-year population projections for Scotland: 03/08/2021

Urinary Tract Infection: 03/08/2021

Carbapenemase producing organisms (CPOs): 03/08/2021

Exceptional Phenotypes: 19/07/2021

Salmonella in humans: 27/09/2021

Animal Antimicrobial Resistance

Antimicrobial resistance (AMR) in companion animal clinical isolates: 29/03/2021

AMR in livestock animal clinical isolates: 29/10/2021

AMR in healthy animals (abattoir): 30/07/2021

Salmonella in animals: 27/09/2021

Release date

16 November 2021

Frequency

Annual

Timeframe of data and timeliness

Antibiotic Use in Humans: Data are for 2016 to 2020 and are timely for this report.

Antibiotic Use in Companion Animals: Data are for 2016 to 2020.

Bacteraemia: Data are for 2016 to 2020 and are timely for this report.

Urinary Tract Infections: Data are for 2016 to 2020 and are timely for this report.

Carbapenemase Producing Organisms (CPOs): Data are for 2016 to 2020 and are timely for this report.

Exceptional Phenotypes: Data are for 2020 and are timely for this report.

***Salmonella* in humans**: Data are from 2016 to 2020 and timely for this report.

AMR in companion animal clinical isolates: Data for clinical isolates from cats and dogs from 2016 to 2020 and are timely for this report.

AMR in livestock animal clinical isolates: Data for clinical isolates from livestock animals from 2016 to 2020, with the exception of *Streptococcus dysgalactiae* and *Klebsiella pneumoniae* for which data was only available for 2019 and 2020.

AMR in healthy animals (abattoir): Data are for 2017 to 2020 and are timely for this report.

***Salmonella* in animals:** Number of laboratory reports from 2016 to 2020. AMR data for 2020 only.

Continuity of data

There are no discontinuities in the reporting period.

Revisions statement

These data are not subject to planned major revisions. However, ARHAI aims to continually improve the interpretation of the data and therefore analysis methods are regularly reviewed and may be updated in the future.

Revisions relevant to this publication

Gram-negative bacteraemia:
Since the previous publication, changes have been made to the data processing methods used to produce antimicrobial susceptibility figures. The new method identifies the most resistant (non-susceptible) isolates from a patient during each 14-day episode of positive blood rather than within each calendar year. The new methods have been applied to historic data to allow year-on-year trend analyses using the same definitions.

Urinary tract infections:
Since the previous publication, changes have been made to the data processing methods used to produce antimicrobial susceptibility figures. The new method identifies the most resistant (non-susceptible) isolates from a patient during each 30-day episode of urinary tract infection rather than within each calendar year. The new methods have been applied to historic data to allow year-on-year trend analyses using the same definitions.

Concepts and definitions

Statistical significance

Please note where an increase or decrease is stated in this report this refers to a statistical change. Where a trend is referred to as stable, there has been no statistically significant increase or decrease. Statistical significance has been determined by a p-value of less than (<) 0.05.

Confidence Intervals

Confidence intervals (95% CI) for proportions were calculated to indicate robustness of the proportions presented. Due to the number of tests being done at the same time a Bonferroni correction has been applied and the p-values adjusted to reflect the number of tests undertaken for each organism. In order to keep the number of multiple testing to a minimum, only organism and drug combinations with enough numbers each year have been tested. Where a 95% CI has been quoted or displayed in a figure as an error bar around a percentage, the method used is the Wilson Score.[41]

Rounding

Please note that due to rounding to 1 decimal place, values may not add to 100%.

Antibiotic Use in Humans

Prescribing data: https://www.isdscotland.org/Health-Topics/Prescribing-and-Medicines/

Occupied bed days: https://www.isdscotland.org/Health-Topics/Hospital-Care/Beds/

Prescribing time period: All trend data are reported for calendar years 2016 to 2020. Data before these time periods may be accessed via older reports which can be found at: https://www.hps.scot.nhs.uk/a-to-z-of-topics/antimicrobial-use-and-resistance/#publications

Population estimates: https://www.nrscotland.gov.uk/files//statistics/population-estimates/mid-20/mid-year-pop-est-20-methodology.pdf

Defined Daily Dose (DDDs, World Health Organisation (WHO)): https://www.whocc.no/atc_ddd_index/

Parenteral antibiotics defined daily doses (DDDs) used to monitor use of intravenous (IV) antibiotics.

Antibiotic Use in Animals

The SAVSNET data were collected via electronic health records within the practice management systems of first opinion veterinary practices (these record species, breed, date or year of birth, sex, nature of condition being treated and antimicrobial treatments supplied, and postcode). These data are submitted voluntarily by participating veterinary practices and therefore cannot be interpreted as being representative of all of Scotland. Nevertheless, they provide additional important intelligence relating to another aspect of antimicrobial use in the One Health ecosystem.

This important data stream allows a continuing impression of antimicrobial use in companion animals in Scotland and will enable practitioners to evaluate their own data compared to these preliminary national data.

SAVSNET website: https://www.liverpool.ac.uk/savsnet/my-savsnet-amr/

Description of the methods used by SAVSNET to capture electronic health records:
Sánchez-Vizcaíno, F., et al. (2015) Small animal disease surveillance. Veterinary Record 177, 591-594. https://bvajournals.onlinelibrary.wiley.com/doi/10.1136/vr.h6174

D.A. Singleton, et al. (2017) Patterns of antimicrobial agent prescription in a sentinel population of canine and feline veterinary practices in the United Kingdom. The Veterinary Journal, Volume 224, Pages 18-24. https://www.sciencedirect.com/science/article/pii/S1090023317300722#bib0090

Description of methods used by SAVSNET for syndromic analysis of antimicrobial prescribing:

D.A. Singleton, et al. (2019) Small animal disease surveillance: gastrointestinal disease, antibacterial prescription and Tritrichomonas foetus. Veterinary Record 10.1136/vr1722 (14th Feb p211-216)

D.A. Singleton, et al. (2019) Small animal disease surveillance 2019: pruritus, pharmacosurveillance, skin tumours and flea infestations. Veterinary Record 10.1136/vr16074 (19th Oct p470-475)

D.A. Singleton, et al. (2019) Small animal disease surveillance 2019: respiratory disease, antibiotic prescription, and canine infectious respiratory disease complex. Veterinary Record (25th May p640-645

Human Antimicrobial Resistance

Case definitions:

Total numbers, incidence rates and antimicrobial susceptibility testing (AST) results were calculated using the following case definitions:

- A new case of bacteraemia is a patient from whom an organism has been isolated from the patient's blood, and who has not previously had the same organism isolated from blood within a 14 day period (i.e. 14 days from date last positive sample obtained).
- A new case of urinary tract infection (UTI) is a patient from whom an organism has been isolated from the patient's urine, and who has not previously had the same organism isolated from urine within a 30 day period (i.e. 30 days from date last positive sample obtained).

Isolate(s) refers to the organism isolated from each case of bacteraemia or UTI.

Please note that the UTI case definition used for this report is based on bacteriuria (bacteria present in urine) and not all cases will be clinically significant UTIs.

With the exception of *Escherichia coli* bacteraemia and *Staphylococcus aureus* bacteraemia, all human bacteraemia data are based only on positive blood results extracted from ECOSS and are not validated cases. *Escherichia coli* bacteraemia and *Staphylococcus aureus* bacteraemia data use validated data collected as part of mandatory surveillance programme as detailed in the ARHAI Scotland Quarterly epidemiological data on *Clostridioides difficile* infection, *Escherichia coli* bacteraemia, *Staphylococcus aureus* bacteraemia and Surgical Site Infection in Scotland.

As part of the NHS Pharmacy First Scotland service, community pharmacists have the ability to supply via patient group direction trimethoprim or nitrofurantoin for uncomplicated UTIs in females aged 16 to 65. This service has been available in all community pharmacies since August 2020 and is likely to have had an impact on the number of urine samples being referred to laboratories since females with uncomplicated UTIs can be treated by pharmacists without attending their General Practitioner.

Incidence rates were calculated as follows:

Bacteraemia rate per 100,000 population = (Number of cases per year / mid-year Scottish population) x 100,000

UTI Rate per 1,000 population = (Number of cases per year / mid-year Scottish population) x 1,000

Population projections: https://www.nrscotland.gov.uk/statistics-and-data/statistics/scotlands-facts/population-of-scotland

Percentage non-susceptibility:

Non-susceptibility is defined as isolates reported as intermediate (I) or resistant (R).

% Non-susceptible = non-susceptible (resistant or intermediate) isolates divided by the total number of isolates tested *100.

Burden of drug resistant infection:

The burden of drug resistant infections is estimated for *Escherichia coli*, *Klebsiella pneumoniae* and *Klebsiella oxytoca*, *Acinetobacter species*, *Pseudomonas aeruginosa*, *Enterococcus faecium*, *Enterococcus faecalis*, *Staphylococcus aureus* and *Streptococcus pneumoniae* bacteraemia cases based on the percentage of organisms resistant (R) to at least one key antibiotic (see Table below).

Antimicrobial susceptibility results are not available for all bacteraemia cases, therefore the % resistance from available results is applied to the total number of bacteraemia cases to provide the estimated number of antibiotic resistant bacteraemias.

Table: Key antibiotics by organisms

Organism(s)	Key antibiotic(s)
Escherichia coli, *Klebsiella pneumoniae* and *Klebsiella oxytoca*	Carbapenems (imipenem, meropenem or ertapenem) Third generation cephalosporins (one of ceftazidime, cefotaxime or ceftriaxone and not carbapenems) Gentamicin (and not carbapenems or third generation cephalosporins) Ciprofloxacin (and not carbapenems or third generation cephalosporins or gentamicin)
Acinetobacter species	Carbapenems (imipenem or meropenem) Aminoglycosides (amikacin or gentamicin) AND ciprofloxacin (and not carbapenems)
Pseudomonas aeruginosa	Carbapenems (imipenem or meropenem) Three or more antimicrobial groups (but not carbapenems)
Enterococcus faecium and Enterococcus faecalis	Vancomycin
Staphylococcus aureus	Meticillin
Streptococcus pneumoniae	Penicillin and macrolides Penicillin (and not macrolides)

Carbapenemase-producing Organisms (CPOs):

The term CPOs encompasses all acquired carbapenemase-producing Gram-negative bacteria and is not limited to carbapenemase-producing *Enterobacterales* (CPEs).

Case definitions can be accessed here: https://www.hps.scot.nhs.uk/web-resources-container/toolkit-for-the-early-detection-management-and-control-of-carbapenemase-producing-enterobacteriaceae-in-scottish-acute-settings/.

Exceptional Phenotypes:

In 2018, the SONAAR team at ARHAI Scotland introduced an electronic process to run a twice weekly interrogation of ECOSS to identify exceptional resistance phenotypes and contact the submitting laboratory requesting confirmation of reported resistance. All alerts are assessed by ARHAI Scotland and if of potential public health concern are drawn to the attention of the wider public health community for appropriate action.

Definitions of an exceptional phenotype can be accessed here: http://www.eucast.org/expert_rules_and_intrinsic_resistance/

Appendix 13 of the National Infection Prevention & Control Manual (NIPCM) contains a mandatory alert micro-organism/condition list. Local monitoring ensures that microbiology clinicians, infection prevention and control teams (IPCTs), health protection teams (HPTs) and antimicrobial management teams (AMT), as appropriate, are aware of each identified case as per local protocols.

The identification of an alert is dependent on laboratories actively performing antimicrobial susceptibility testing (AST) and submitting results to ECOSS. This may result in underreporting, or no reporting, of a particular micro-organism/antibiotic resistance combination if there is limited or no testing performed.

Animal Antimicrobial Resistance

AMR in animal clinical isolates:

The data from veterinary clinical isolates are subject to a number of important biases. Unlike the clinical samples in humans in Scotland, the samples are tested on a 'charged for' basis to inform private veterinary treatment of diseased animals. There is a cost to the animal keeper that affects the submission of samples to these services. In addition, the primary purpose of screening for AMR is to inform veterinary treatment and they are tested against a panel of antimicrobials relevant for that purpose at, where they exist, species-relevant clinical breakpoints, based on British Society for Antimicrobial Chemotherapy (BSAC) breakpoints.

AMR in healthy animals (abattoir):

Data presented here represent the percentage of non-susceptible isolates over all tested isolates. These isolates are from healthy livestock animals and are tested against a panel of antimicrobials, and at breakpoints, relevant to human clinical isolates. Database represents a non-random sample of veterinary practices and isolates, based on voluntary submission of data and/or samples to SRUC.

Changes in European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints for 2020 have been applied to healthy animal data for all antibiotics except tetracycline which uses the Clinical and Laboratory Standards Institute (CLSI) breakpoint value. These breakpoints are the agreed microbiological thresholds at which resistance is considered to be present. Changes to breakpoints have been applied retrospectively to allow year on year comparisons.

Salmonella:

Interpretation of *Salmonella* resistance to individual antibiotics is complicated by the fact that in some subtypes there are well-recognised genetic elements encoding resistance to multiple agents. Thus, the occurrence of resistance to individual antibiotics is not always independent and the apparent prevalence of resistances to different agents can be strongly influenced by the abundance of *Salmonella* sub-types in the sample set for each reporting period.

In Scotland, *Salmonella* is a reportable animal pathogen; all veterinary diagnostic laboratories isolating *Salmonella* spp. from livestock in Scotland are also required to forward suspect

isolates for confirmation and typing to the SMiRL. No information on prior antibiotic treatment is available for *Salmonella* isolates identified from animal samples.

The submission of samples is affected by the willingness of an animal keeper to pay the costs of laboratory testing to inform treatment, in addition to the clinical presentation in the affected animal(s). A number of *Salmonella* spp. are adapted to particular animal host species and are only found rarely in others. Generally, *Salmonella* infection in animals can result in clinical syndromes suggestive of bacteraemia and systemic illness and, in these cases, antibiotic therapy would sometimes be part of the treatment regimen instituted by an attending veterinarian. Vaccines against some serotypes of *Salmonella* spp. are available for some animal species, and are used to a greater of lesser extent depending on a number of factors including assessed risk of infection in the particular group of animals.

Relevance and key uses of the statistics

Making information publicly available. The report is intended to support planning, prioritisation and evaluation of initiatives to optimise antimicrobial use and to minimise antimicrobial resistance

Accuracy

Antibiotic Use in Humans

Antibiotic use in primary care: A subset of these data are routinely validated by Practitioner Services on a monthly basis.

Healthcare associated denominator, total occupied bed days: Sum of OBDs for all hospitals in numerator, standardised methodology used.

Antibiotic Use in Animals

Data provided by SAVSNET from a non-random sample of veterinary practices. Analyses carried out by ARHAI Scotland and results quality assured by SAVSNET data provider.

Human Antimicrobial Resistance

Bacteraemia: Data supplied by United Kingdom Accreditation Service (UKAS) accredited laboratories using standardised testing methodologies.

Urinary Tract Infections: Data supplied by UKAS accredited laboratories using standardised testing methodologies.

Carbapenemase Producing Organisms (CPOs): Data supplied by UKAS accredited laboratories using standardised testing methodologies.

Exceptional Phenotypes: Data supplied by UKAS accredited laboratories using standardised testing methodologies. Exceptional phenotypes are confirmed with the sending laboratory.

Animal Antimicrobial resistance

Data supplied by UKAS accredited laboratories using standardised testing methodologies. SRUC (ISO:17025), SMiRL, Glasgow (ISO:15189).

Completeness

Antibiotic Use in Humans: All data for the reporting period have been included in the analysis.

Antibiotic Use in Animals: Database represents a non-random sample of veterinary practices based on voluntary submission of data to SAVSNET.

Human Antimicrobial Resistance

Bacteraemia: All data for the reporting period have been included in the analysis.

Urinary Tract Infections: All data for the reporting period have been included in the analysis.

Carbapenmase Producing Organisms (CPOs): All data for the reporting period have been included in the analysis.

Exceptional Phenotypes: All laboratory confirmed isolates have been included in the analysis.

Animal Antimicrobial Resistance

AMR in companion animal clinical isolates: Database represents a non-random sample of veterinary practices and veterinary isolates, based on voluntary submission to SAVSNET.

AMR in livestock animal clinical isolates: Database represents a non-random sample of veterinary practices and veterinary isolates, based on voluntary submission of data and/or samples to SRUC.

AMR in healthy animals (abattoir): Samples are collected on a monthly basis from livestock animals presenting at abattoirs and submitted to SRUC.

Salmonella: All laboratory confirmed isolates have been included in the analysis.

Comparability

Antibiotic Use in Humans

The numerator for antibiotic use includes the number of WHO defined daily doses (DDDs) and is comparable to other antibiotic use surveillance programmes using this method.

Occupied bed days (OBDs), is derived using a standardised methodology used allowing comparability across years.

Antibiotic Use in Animals

Comparable to prescribing databases from ISD.

Human Antimicrobial Resistance

Bacteraemia:

Public Health England report on national data on antibiotic resistance: https://www.gov.uk/government/publications/english-surveillance-programme-antimicrobial-utilisation-and-resistance-espaur-report

ECDC report on Antimicrobial resistance surveillance in Europe https://www.ecdc.europa.eu/en/antimicrobial-resistance/surveillance-and-disease-data/report

Escherichia coli and *Staphylococcus aureus* bacteraemia: ARHAI Scotland Quarterly epidemiological data on *Clostridioides difficile* infection, *Escherichia coli* bacteraemia, *Staphylococcus aureus* bacteraemia and Surgical Site Infection in Scotland.

ARHAI HAI Annual report: https://www.hps.scot.nhs.uk/web-resources-container/healthcare-associated-infection-annual-report-2020/

The incidence of *E. coli* bacteraemia in the HAI Annual report (77.0) was calculated using mid-2019 population estimate whereas the calculation in this report used mid-2020 population estimate which became available on 25 June 2021.

Urinary Tract Infection:

Public Health England report on national data on antibiotic resistance: https://www.gov.uk/government/publications/english-surveillance-programme-antimicrobial-utilisation-and-resistance-espaur-report.

Carbapenemase producing Organisms (CPOs):

Public Health England report on Carbapenem resistance https://www.gov.uk/government/collections/carbapenem-resistance-guidance-data-and-analysis

ECDC report on Carbapenem resistance https://ecdc.europa.eu/en/surveillance-atlas-infectious-diseases

Exceptional Phenotypes: N/A

Animal Antimicrobial resistance

SRUC data from healthy livestock animals are tested against a panel of antimicrobials, and at breakpoints, relevant to human clinical isolates so that AMR results are comparable. European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints for 2020 have been applied for all antibiotics except tetracycline which uses the Clinical and Laboratory Standards Institute (CLSI) breakpoint value. These breakpoints are the agreed microbiological thresholds at which resistance is considered to be present. Changes to breakpoints have been applied retrospectively to allow year-on-year comparisons.

Accessibility

It is the policy of NSS to make its web sites and products accessible according to published guidelines.

Coherence and clarity

Tables and charts are accessible via our website at: https://www.hps.scot.nhs.uk/sonaar/

Value type and unit of measurement

Antibiotic Use in Humans: The number of items per 1,000 population in Scotland per day (items/1000/day) and total DDD per 1,000 population per day (DDD/1000/day).

Antibiotic Use in Animals: Counts and percentages of antibiotic prescriptions by antibiotic class, animal species, administration routes, and main presenting problems.

Human Antimicrobial Resistance

Bacteraemia:

Number of cases and incidence rates (per 100,000 population).

AMR data includes percentage non-susceptible (I & R categories) for antibiotic/organisms combinations

Urinary Tract Infections:

Number of cases and incidence rates (per 1,000 population).

AMR data includes percentage non-susceptible (I & R categories) for antibiotic/organisms combinations.

Carbapenemase Producing Organisms (CPOs):

Number of isolates, number of carbapenemase producers by organisms and enzyme type and incidence per 100,000 population.

Exceptional phenotypes:

Number of confirmed exceptional phenotype, number of exceptional phenotypes per organism/antibiotic combination.

Animal Antimicrobial resistance

AMR in companion animal clinical isolates: Counts and percentage of non-susceptible isolates over all tested isolates.

AMR in livestock animal clinical isolates: Counts and percentage of non-susceptible isolates over all tested isolates.

AMR in healthy animals (abattoir): Counts and percentage of non-susceptible isolates over all tested isolates.

Disclosure

The NSS protocol on Statistical Disclosure Protocol is followed.

Official Statistics designation

Not Assessed

UK Statistics Authority Assessment

Not Assessed

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Help email

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Appendix 3 – Early access details

Pre-Release Access

Under terms of the "Pre-Release Access to Official Statistics (Scotland) Order 2008", ARHAI is obliged to publish information on those receiving Pre-Release Access ("Pre-Release Access" refers to statistics in their final form prior to publication). The standard maximum Pre-Release Access is five working days. Shown below are details of those receiving standard Pre-Release Access.

Standard Pre-Release Access:

- Scottish Government Health Department
- NHS Board Chief Executives
- NHS Board Communication leads

Appendix 4 – ARHAI Scotland and Official Statistics

About ARHAI Scotland

ARHAI Scotland works at the very heart of the health service across Scotland, delivering services critical to frontline patient care and supporting the efficient and effective operation of NHS Scotland.

Official Statistics

Our statistics comply with the Code of Practice for Statistics in terms of trustworthiness, high quality and public value. This also means that we keep data secure at all stages, through collection, processing, analysis and output production, and adhere to the 'five safes'.

Reference List

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(3) National Institute for Health and Care Excellence. Antimicrobial Prescribing Guidelines. National Institute for Health and Care Excellence (NICE). 2019. Available from: URL: https://www.nice.org.uk/guidance/health-protection/communicable-diseases/antimicrobial-stewardship

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