Scottish One Health Antimicrobial Use and Antimicrobial Resistance in 2017.

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Antimicrobial resistance (AMR) remains a major public health issue. AMR occurs when microorganisms, such as bacteria, adapt the ability to survive exposure to a treatment that would normally kill them. Inappropriate and unnecessary antibiotic use speeds up the development of AMR. A ‘One Health’ approach is required to tackle AMR and its drivers across all settings (humans, animals and the environment).

This report describes a range of AMR and antimicrobial use (AMU) data in human, and animal infections.

### ANTIBIOTIC USE IN HUMANS

- 3.0% decrease in antibiotic use in humans between 2013 and 2017
- The majority of antibiotic use in humans occurs in primary care (79.3%)
- 7.8% decrease in antibiotic use in primary care between 2013 and 2017 and in 2017, the rate of antibiotic use in primary care was the lowest on record
- However the use of antibiotics in Scotland’s acute hospitals was 18.0% higher than in 2013
- As part of the transformation in roles of different healthcare professionals, nurses are now responsible for the second highest proportion of antibiotic prescribing in the community (8.4%).

### ANTIMICROBIAL RESISTANCE IN HUMANS

- The incidence of *Escherichia coli*; the most common cause of bacteraemia, has increased over the period 2013 to 2016, but has remained stable over the last year
- The proportions of *E. coli* bacteraemia isolates non-susceptible to commonly used antibiotics were generally stable over the last five years; however, resistance to some antibiotics was consistently high
- The incidence and non-susceptibility of other Gram-negative bacteraemias (*Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Klebsiella oxytoxa* and *Acinetobacter* spp.) have remained stable over the last five years
- There were 108 carbapenemase-producing organisms (CPOs) reported in 2017. There has been a 39% year on year increase in the incidence of reported CPO isolates since 2013
- In the last year there has been a 4.5% decrease in the number of reported urinary tract infections (UTIs) caused by *E. coli* and in the last five years a decrease in the non-susceptibility to the most commonly used antibiotics
- The incidence of *E. faecium* bacteraemia has remained stable since 2013; however non-susceptibility to vancomycin has increased by 26.9% year on year over this period. In 2017 40.8% of *E. faecium* bacteraemia isolates were non-susceptible to vancomycin
- In 2017 there were 2,610 episodes of reported gonorrhoea infection. Ceftriaxone non-susceptibility was not observed, however high level azithromycin resistance (HL-AziR) was reported in 1.6% of episodes. There were no treatment failures recorded.
Antimicrobial resistance (AMR) remains a major public health issue. AMR occurs when microorganisms, such as bacteria, adapt the ability to survive exposure to a treatment that would normally kill them. Inappropriate and unnecessary antibiotic use speeds up the development of AMR. A ‘One Health’ approach is required to tackle AMR and its drivers across all settings (humans, animals and the environment).

This report describes a range of AMR and antimicrobial use (AMU) data in human, and animal infections.

### ANTIMICROBIAL RESISTANCE IN ANIMALS

- In samples collected from animals entering the food chain, the levels of non-susceptibility in *E. coli* from poultry and pigs were greater than those detected from cattle and sheep.
- The number of reports of *Salmonella* in animals has remained relatively stable over the last five years with 233 recorded in 2017. Of these, 72.1% of *Salmonella* isolates reported from animals were fully susceptible to all antibiotics tested.
- Data from veterinary clinical isolates have shown that non-susceptibility to antibiotics tested has remained stable over the last five years.

### CONCLUSIONS

- AMR remains a serious threat to public health across the world.
- Antibiotic resistant infections are more difficult to treat.
- Misuse of antibiotics is the main driver for the development of AMR.
- The total use of antibiotics is reducing; however, use of antibiotics in acute hospitals is increasing.
- AMR in humans is generally stable in Scotland, however, for some important organisms non-susceptibility is increasing.
- In animals, AMR is also generally stable.
- The ‘One Health’ approach is essential for the control of AMR.
- Human and animal health professionals together with the public need to work together to preserve the effectiveness of antimicrobials for the future.
Introduction

Antimicrobial resistance (AMR), the ability of microbes to develop resistance to antimicrobials, rendering infections more difficult and in some rare instances, impossible to treat, is recognised as a global public health threat, compounded by the current lack of new antibiotics being developed. In recent years this threat has been met with an intensified response both nationally and internationally, via, for example, the World Health Organisation (WHO) Global Action Plan (2015), the European One Health Action Plan against Antimicrobial Resistance (2017), and the 2016 United Nations Political Declaration on AMR.

Consistent with these initiatives, the UK Five Year AMR strategy (2013-2018) aimed to slow the development and spread of AMR. Scotland has a complementary multi-agency plan led by the Chief Medical Officer (CMO) and Chief Nursing Officer (CNO) which also feeds into a number of UK level groups.

An essential component of any AMR plan, the surveillance of AMR and antimicrobial use (AMU) enables, for example, detection of areas of concern, and the assessment of the effectiveness of interventions to control the development of AMR.

This, the second ‘Scottish One Health AMU and AMR Annual Report’, (SONAAR) tracks the changes in AMU in humans in Scotland including total prescribing, prescribing in primary care and prescribing in acute hospitals. We also report on the levels of resistance in a broad range of human infections, including for the first time resistance in candidaemia, and in the sexually transmitted organism Mycoplasma genitalium.

These data are used by the Scottish Antimicrobial Prescribing Group (SAPG) and others to inform antimicrobial prescribing policy, and to the develop initiatives to minimise inappropriate antimicrobial prescribing. The Scottish Microbiology and Virology Network (SMVN) Antimicrobial Susceptibility Testing (AST) subgroup which, in collaboration with the Scottish Reference Laboratories and Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit, Public Health England (PHE), provides advice on microbiological testing strategies for diagnostic NHS diagnostic laboratories in Scotland.

Further, following many years of reporting solely on human AMU and AMR, in 2017 data relating to resistance among organisms from animals were incorporated in to this report. This move recognised the importance of the ‘One Health’ ethos to the sustainable control of AMR, i.e. the concept that the interconnectedness of the health of humans, animals, and the environment necessitates an approach which takes all spheres into account rather than focussing on one to the exclusion of others. While animal AMR surveillance systems are still developing, these data give an indication of the levels of resistance in organisms from animals which has the potential to inform veterinary antimicrobial prescribing policy and contribute to understanding the links between, human and animal AMR.

Taken together, the human antimicrobial prescribing, and human and animal AMR data presented in this report, as well as examples illustrative of the ways in which Scotland is responding to the global AMR threat, provide an overview of the current AMR picture in Scotland for the public, professionals and policy makers.

Lastly it is not a coincidence that this report is being published around the time of European Antibiotic Awareness Day and World Antibiotic Awareness Week. It provides data which reinforces the message that antibiotics must be used carefully if they are to work in the future.
Human Antimicrobial Use

Antibiotic use in humans

Antibiotics prevent and treat infections by killing bacteria but an increasing number of bacteria no longer respond to an antibiotic to which they were originally susceptible. This is known as antibiotic resistance. The development of antibiotic resistance is a complex evolutionary process; however, the main reason for antibiotics losing their effectiveness is their overuse and misuse. While the number of drug resistant infections has increased, it has been 30 years since a new class of antibiotic was introduced.

To safeguard antibiotics now and for the future it is vital for all clinicians to promote their careful and appropriate use. Work is needed to make the public aware that taking antibiotics for minor infections when they are not needed increases the risk of developing drug resistant infections. Drug resistant infections are more difficult to treat. An antimicrobial stewardship programme (ASP) is coordinated by the SAPG. Antimicrobial stewardship is a programme of coordinated activities to optimise antibiotic prescribing to improve patient outcomes, reduce antibiotic resistance, and decrease the spread of infections caused by multi-drug resistant organisms.

One key element of antimicrobial stewardship is to reduce unnecessary use of antibiotics. This can be achieved by reducing their use for self-limiting infections like coughs and colds and ensuring that the right antibiotics are used for the right duration when they are required. In 2017, the total use of antibiotics in humans was 25.5 defined daily doses (DDD) per 1,000 population per day (DDD/1,000/day); 3.0% lower (p<0.001) than in 2013 (Figure 1). While this means progress is being made in Scotland, further reductions are possible and required to reduce the development of drug resistant infections. Comparing antibiotic use in Scotland with use in other countries is influenced by differences in disease burden, health systems and data availability in addition to patterns of prescribing but it is known that the rate of antibiotic use in Scotland is around twice that of countries such as the Netherlands.¹

The majority of antibiotic use in 2017 occurred in primary care (general practice) (79.3%), followed by use in acute hospitals (14.4%), dentistry (3.7%) and non acute hospitals (2.6%) (Figure 2). Clinicians in all settings can help to optimise antibiotic use and help preserve this valuable resource.

Figure 1: Total use of antibiotics in humans, DDD/1,000/day, 2013 to 2017.

3.0% decrease in antibiotic use in humans between 2013 and 2017
“The threat from antibiotic resistant infections is real and affects all of us. Already in some parts of the world certain infections have become untreatable due to antibiotic overuse and resistance. Similarly many aspects of health care that we take for granted such as routine surgery or chemotherapy could become much more hazardous due to lack of useful antibiotics to prevent or treat infectious complications. It is vital that action to improve antibiotic use is increased. Healthcare workers and the public need to understand and value the importance of this precious resource.”

Dr. Andrew Seaton, Consultant in Infectious Disease, Chair of Scottish Antimicrobial Prescribing Group

Figure 2: Total antibiotic use by prescriber type, DDD/1,000/day, in 2017.

Another key element of antimicrobial stewardship is to avoid unnecessary use of powerful broad-spectrum antibiotics. Most infections are treated empirically, where the prescriber has not yet identified the bacteria causing the infection and does not know the suspected bacteria’s susceptibility to antibiotics. Prescribing guidelines for treatment of infection in hospitals and the community have been developed by NHS board Antimicrobial Management Teams (AMTs) to provide clinicians with advice on empirical antibiotic choice and duration of treatment for common infections. To tackle the global problems of antibiotic resistance the World Health Organisation (WHO) has grouped antibiotics into three categories: Access; Watch; and Reserve. The Access group contains antibiotics that should be used as first line treatment for the most common infections and these feature in empirical antibiotic guidelines. In 2017, 60.6% of antibiotics used in humans in Scotland across all healthcare settings were from the Access group of antibiotics. This suggests clinicians are following prescribing guidelines.

Key Points
- It is important to safeguard antibiotics through optimising how they are used now and in the future
- Antibiotic use in humans has decreased by 3.0% since 2013
- The majority of antibiotic use occurs in primary care
- Over 60% of antibiotics used in 2017 were Access group antibiotics which are recommended for first line treatment of infection
- The antimicrobial stewardship programme must continue to support clinicians to achieve further improvements in antibiotic use.
Antibiotic use in primary care

In Scotland in 2017, 79.3% of antibiotic use in humans occurred in primary care (general practice). Reducing antibiotic use for minor infections such as sore throat, sinusitis and coughs where antibiotics are seldom required in otherwise healthy individuals is an important part of safeguarding antibiotics for the future.

In 2017, the use of antibiotics in primary care (general practice) was 1.92 items per 1,000 population per day; 7.8% lower (p<0.001) than in 2013 (Figure 3). This is the fifth consecutive annual decrease and means that antibiotic prescribing in primary care is at its lowest point since data became available in 1993. The proportion of the Scottish population that received at least one course of antibiotics was 28.3% in 2017 compared to 31.5% in 2013. This is the lowest proportion since data became available in 2010.

When antibiotics are required in primary care, clinicians use local evidence based prescribing guidelines to select the initial choice of treatment. These prescribing guidelines are intended to promote the use of narrower-spectrum antibiotics (Access group) and restrict the use of broad-spectrum antibiotics (Watch group) to a limited number of infections where they are required. Minimising the use of broad-spectrum antibiotics is important to avoid further development of drug resistant infections. In 2017, 75.2% of antibiotics used in primary care were from the Access group suggesting that clinicians are following local primary care prescribing guidelines.

Across Scotland clinicians in primary care have achieved success in reducing unnecessary antibiotic use but more needs to be done. There is evidence that although only 10% of patients with sore throat and 20% of patients with sinusitis benefit from antibiotics, a much greater proportion of people with these symptoms receive antibiotics. Many clinical teams are already taking steps to reduce antibiotic use by identifying those patients who really need antibiotics and providing reassurance and self-care advice to those who do not need them. Optimising antibiotic use will slow the development of resistance and help preserve the effectiveness of the antibiotics currently available.

Figure 3: Antibiotic use in primary care, items/1,000/day, 2013 to 2017.
“It is reassuring to see the year on year reductions in antibiotic use in primary care since 2013, which reflects the efforts of healthcare professionals and the public to improve how we use antibiotics, but it is not enough. We still use too many antibiotics for self-limiting infections with consequences for the person treated and for future generations with the increase in antibiotic resistance. We should all redouble our efforts to find innovative ways to further reduce antibiotic use.”

Dr. Gail Haddock, General Practitioner, NHS Highland, Vice-chair of Scottish Antimicrobial Prescribing Group

Scotland’s NHS is changing to meet the needs and demands placed on health and social care to provide sustainable quality services. It is recognised that to maintain and improve Scotland’s health, community care will be transformed with care provided within multidisciplinary teams. Part of this transformation is an evolution in the roles of different healthcare professionals. Antibiotic prescribing was once mainly undertaken by general practitioners (GPs) but in 2017 the face of antibiotic use in primary care is changing (Figure 4).

Figure 4: Antibiotic prescribing in the community, items/1,000/day, 2013 and 2017.

Key Points
- The majority of antibiotic use in humans occurs in primary care
- Antibiotics are not required in most people with minor infections
- Reducing unnecessary antibiotic use will slow the development of antibiotic resistance
- Antibiotic use in primary care has decreased by 7.8% since 2013
- In 2017 the rate of antibiotic use in primary care was the lowest on record
- Over 75% of antibiotics used in 2017 were Access group antibiotics which are recommended for first line treatment of infection
- The antimicrobial stewardship programme must continue to support clinicians to achieve further improvements in antibiotic use.
The changing face of antibiotic use in the community - antibiotic use by nurse prescribers

An important milestone in antibiotic use in Scotland was reached in 2017. While GPs remained accountable for the majority (83.8%) of antibiotic use in primary care, nurse prescribers have overtaken dentists and are now the group responsible for the second highest proportion of antibiotic use in the community. Since 2013 there has been a 93.6% (p<0.001) increase in antibiotic use by nurse prescribers accounting for 8.4% of antibiotic use in the community in 2017.

Figure 5: Antibiotic prescribing by nurse prescribers in primary care, items/1,000/day, 2013 to 2017.

All nurses can contribute to antimicrobial stewardship through safe management and administration of antibiotics. In 2017, 86.1% of antibiotics used by nurse prescribers were Access group antibiotics. The ten most commonly used antibiotics by nurses accounted for 95.8% of all nurse antibiotic prescribing in 2017. This suggests that nurse prescribers are following the local prescribing guidelines used by all clinicians when making their treatment choices.

With the transformation of service delivery in primary care it is likely that the direct impact of nurse prescribers on antibiotic use in Scotland will continue to grow. It is important that this new group of prescribers is adequately supported and included in a team approach to stewardship. The SAPG has included nurses as group members since its inception and now has a nurse antimicrobial stewardship subgroup to support local and national stewardship initiatives involving nurses. This has included a workbook on antimicrobial stewardship for nurses and midwives which is being further developed as a digital asset and includes a section aimed at nurses working in community settings.

“The way antibiotics are being prescribed is changing. Care of patients with suspected infections will continue to evolve and nurses will work within multidisciplinary teams prescribing antibiotics when they are clinically required but increasingly educating and reassuring patients that antibiotics are not usually required for minor infections.”

Professor Fiona McQueen, Chief Nursing Officer, Scottish Government.
The changing face of antibiotic use in the community - antibiotic use by dentists

Dentists can prescribe a limited range of antibiotics on NHS prescriptions (GP14) in Scotland. The Scottish Dental Clinical Effectiveness Programme (SDCEP) has produced guidance on infection management including recommendations on when antibiotics should be prescribed, recommended empirical treatment, dose and duration.

Since 2013 there has been a 24.5% (p<0.001) decrease in antibiotic use by dentists accounting for 7.4% of antibiotic use in the community. In 2017, the rate of antibiotic prescribing by dentists was 0.15 items per 1,000 population per day. This is the lowest rate on record. There is evidence from clinical audits which estimates that up to half of dental prescriptions for antibiotics may be inappropriate and these data suggest that dentists are making continued progress toward the ambition of reducing unnecessary antibiotic use.

Figure 6: Antibiotic prescribing by dentists in primary care, items/1,000/day, 2013 to 2017.

The SAPG has established a dental antimicrobial stewardship subgroup to maximise good practice opportunities for optimisation of antibiotic use by dentists in Scotland. In 2017, four antibiotics: amoxicillin (67.7%), metronidazole (28.3%), erythromycin (1.9%) and phenoxymethylpenicillin (0.7%) accounted for 99.6% of dental antibiotic use. The next phase is for the SAPG dental subgroup to go beyond the volume of antibiotics used by dentists and investigate in more detail prescribing patterns for metronidazole and the narrower spectrum phenoxymethylpenicillin.

“Antibiotics should rarely be the first line treatment to deal with acute dental infections, these are best resolved by some form of dental surgical intervention. Prevention of dental disease in the first case is a key public health priority. The decrease in dental antibiotic prescribing over the last five years is good news but more must be done to protect this important resource. I’m very pleased to be working with the SAPG multidisciplinary stewardship group involving many of the dental specialties to address this challenge.”

Professor Andrew Smith, Consultant Microbiologist Glasgow Dental School, Chair of SAPG dental subgroup.
The changing face of antibiotic use in the community - antibiotic use by pharmacists

Community pharmacies across Scotland are often the first port of call for people seeking health and medicines advice. Community pharmacy staff have contributed to antibiotic stewardship through provision of self-care advice for common infections to avoid unnecessary antibiotic use and identifying patients with alarm symptoms that need referral to general practice.

In 2017, community pharmacy’s antibiotic stewardship role increased with the introduction of Pharmacy First. This Scottish Government scheme aims to encourage patients with certain minor ailments to use their community pharmacy for treatment rather than making a GP appointment. All pharmacists involved undertook education and training to support this role. Following successful pilots the scheme was rolled out across Scotland in 2017 focussing on management of uncomplicated urinary tract infection (UTI) in women aged 16 to 65 years and impetigo in any age group. Community pharmacists carry out a patient consultation and provide advice and treatment if required under locally agreed patient group directions. The service is available both within GP opening hours and out of hours.

In 2017 there were 16,031 antibiotic prescriptions written and dispensed by community pharmacists in Scotland. Although this represents only 0.5% of antibiotic use in primary care, pharmacist prescribing of antibiotics has increased year on year since 2013 (Table 1).

<table>
<thead>
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<td>Number of prescriptions</td>
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<td>1,867</td>
<td>3,000</td>
<td>8,070</td>
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In 2017, 82% of pharmacist antibiotic prescriptions were for trimethoprim. This mainly reflects the roll out across Scotland of the Pharmacy First UTI consultation service. Some NHS boards have also established local schemes where patients can consult their community pharmacist for: skin infections; exacerbation of chronic obstructive pulmonary disease (COPD); and for chlamydia testing and treatment.

The other antibiotics frequently prescribed by pharmacists included: flucloxacillin (3.2%), the antibiotic of choice for skin infections; amoxicillin (3.0%), first line for COPD; and azithromycin (2.8%), first line following a positive test for chlamydia.

As part of the transformation of primary care community pharmacists will increasingly work as part of multidisciplinary teams using their clinical skills to optimise medicines use. The Pharmacy First scheme is a step towards all pharmacists being trained as independent prescribers. It is important this new group of prescribers is adequately supported and included in a team approach to antimicrobial stewardship. There is potential to further utilise community pharmacists to provide near patient diagnostic testing for suspected infections to ensure early intervention and reduce unnecessary use of antibiotics.

“The Scottish Antimicrobial Prescribing Group and the Royal Pharmaceutical Society are committed to supporting community pharmacists and their staff to maximise the opportunities to manage common infections effectively and preserving the effectiveness of antibiotics.”

Antibiotic use in acute hospitals

In hospitals antibiotics are required for the treatment of a range of infections often among people with co-morbidities and/or those caused by multi-drug resistant pathogens. Antibiotics are also used to prevent infections following surgery, transplants and cancer chemotherapy. Antibiotics are commonly used in hospitals with around one in three people in Scottish hospitals receiving antibiotics on any given day.

Few new antibiotics have been launched in recent years and those currently in development tend to be new combinations of existing classes of drugs for use in a small number of infection types. This means optimising use of the currently available antibiotics is vital to prevent further resistance and preserve their effectiveness. Antimicrobial stewardship in hospitals focuses on the ‘Five Rights’ - the right choice of antibiotic, at the right dose and right frequency, by the right route, for the right duration, which will ensure effective treatment and cause the least harm to the patient and to future patients. In Scotland in 2017 14.4% of antibiotic use in humans occurred in acute hospitals. The use of antibiotics in Scotland’s acute hospitals in 2017 was 1656 DDD per 1,000 occupied bed days (OBDs); 18.0% higher (p<0.001) than in 2013.

Giving unnecessary antibiotics in acute hospitals constitutes antibiotic misuse and reducing use is a key element of antimicrobial stewardship. However, antibiotics are vital for patients with and at risk from infection and not giving antibiotics when they are clinically needed also represents antibiotic misuse. The way antibiotics must be used in hospitalised patients is a balance between obtaining the best clinical outcomes for patients and minimising harm to the person receiving antibiotics, and to the population through development of drug resistant infections.

Recognising and managing infection promptly has been the focus of national work on sepsis. In practical terms this means intravenous (IV) antibiotics are started based on signs and symptoms that suggest infection. The use of IV antibiotics accounted for 32.9% of total antibiotic use in 2017 compared with 29.4% in 2013. The SAPG has commenced work to support a standardised approach to the review of patients receiving IV antibiotics as well as the documentation of the recommended duration of oral antibiotics on the prescription chart. It is anticipated that this development will reduce patient exposure to unnecessary antibiotics and in turn lead to a reduction in total use of antibiotics. Switching patients from IV to oral antibiotics as soon as the patient’s condition allows enables the removal of vascular devices. The early removal of vascular devices reduces the risk of device-related infections, including Staphylococcus aureus bacteraemias, and potentially allows earlier discharge from hospital.
The SAPG has developed an aide memoire for clinicians to support reliable review of patients receiving IV antibiotics within daily ward round documentation.

While work on clinical review of patients receiving antibiotics is vital, reducing unnecessary use of broad-spectrum antibiotics remains an important way to optimise antibiotic use. The benefits include reducing the selection pressure for development of drug resistant infections, and preserving broad-spectrum antibiotics for use when other antibiotics have failed such as in complex infections caused by multi-drug resistant bacteria. In 2017, 60.7% of antibiotic use in acute hospitals belonged to the Access group of antibiotics. This suggests that while clinicians are following hospital prescribing policies, there may be room for further improvement.

Initial antibiotic choice for some patients will be affected by whether the patient has any drug allergies. Approximately 10% of patients are labelled as being penicillin allergic but the vast majority have not experienced a true allergic reaction, rather another type of adverse reaction, often a gastric upset, which has been incorrectly referred to as an allergy. The SAPG has commenced pilot work to distinguish between those patients who have experienced a true allergic reaction, in whom penicillin must be avoided and those who have not so that inappropriate allergy labels can be removed.

Key Points

- Antibiotics are used in hospitalised patients for the treatment of infections often in people with other co-morbidities and/or those with multi-drug resistant pathogens
- Antibiotics are also used to prevent infections following surgery, transplants and cancer chemotherapy
- Antibiotic use in acute hospitals has increased by 18% since 2013
- Over 60% of antibiotics used in 2017 were Access group antibiotics which are recommended for first line treatment of infection
- Few new antibiotics are under development and optimising use of the currently available antibiotics is vital to preserve their effectiveness

“Antibiotics save lives in people with serious infections but we need all clinical teams to take responsibility for protecting antibiotics for the future by regular review of patient’s antibiotic plan and to stop antibiotics when they are no longer needed. This approach of rational, safe and effective use of antibiotics is in line with Realistic Medicine model of practice.”

Dr. Stephanie Dundas, Consultant in Infectious Disease, Lead clinician for Scottish Antimicrobial Prescribing Group antibiotic review group.

Over 60% of antibiotics used in acute hospitals in 2017 were Access Group (first line)
Antimicrobial Resistant Infections

Gram-negative bacteraemia

Gram-negative bacteria are an important cause of serious infections in both healthcare and community settings. Globally, the prevalence of Gram-negative infections is increasing and in many settings, the morbidity and mortality attributable to resistant Gram-negative serious infections is higher than that associated with Gram-positive infections.\textsuperscript{3,4}

*Escherichia coli* were the most common cause of Gram-negative bacteraemia in 2017, followed by *Klebsiella pneumoniae, Pseudomonas aeruginosa, Klebsiella oxytoca* and *Acinetobacter* spp. (Figure 8).

**Escherichia coli** bacteraemia

In 2017, there were 4,763 cases of *E. coli* bacteraemia in Scotland compared with 4,802 in 2016. The incidence of *E. coli* bacteraemia in Scotland in 2017 was 87.8 per 100,000 population, with no change from the previous year evident. In comparison, the incidence of *E. coli* bacteraemia in England was 74.6 per 100,000 population in 2017.\textsuperscript{5}

While there was an increasing year on year trend of 1.4% (\(p = 0.003\)) in the incidence of *E. coli* bacteraemia in the period 2013 to 2017 (Figure 8), there was no increase observed when comparing 2016 with 2017.

As noted in previous reports the incidences of the other most common Gram-negative bacteraemias in 2017 were much lower than those of *E. coli*.

**Figure 8: Incidence (per 100,000 population) of Gram-negative bacteraemia due to the most commonly reported bacteria, 2013 to 2017.**

\[1.4\% \uparrow\] year on year increase in *E. coli* bacteraemia between 2013 and 2017
Susceptibility of *E. coli*

The proportion of *E. coli* bacteraemia isolates non-susceptible (resistant or intermediate) to commonly used antibiotics was generally stable over the last five years (Figure 9).

In 2017, 64.7% of isolates were non-susceptible to amoxicillin, 31.5% were non-susceptible to co-amoxiclav and 20.3% were non-susceptible to ciprofloxacin. Notably, 17.0% of isolates were non-susceptible to cefuroxime, an increase from 14.4% on the previous year (p=0.001). In contrast, there has been an 11.0% year on year decrease over the last five years in non-susceptibility to ceftriaxone (p=0.002), which was 6.3% in 2017.

*E. coli* bacteraemia isolates were typically susceptible to most other tested agents. All bacteraemia isolates were susceptible to meropenem. These findings are broadly comparable to equivalent Public Health England (PHE) data.⁶

**Figure 9: Proportions of *E. coli* bacteraemia isolates non-susceptible to commonly used antibiotics, 2013 to 2017.**
Other Gram-negative bacteraemia

*Klebsiella pneumoniae*

In 2017, 833 cases of *K. pneumoniae* bacteraemia were reported. The incidence was 15.4 per 100,000 population, with the rate remaining stable over the last five years (Figure 8).

**Susceptibility of *K. pneumoniae***

Susceptibility among *K. pneumoniae* bacteraemia isolates has generally remained stable over the last five years (Figure 10). Isolates were typically susceptible to most tested agents. In 2017, three bacteraemia isolates were resistant to meropenem and confirmed as carbapenemase producers. Susceptibility trends among *K. pneumoniae* bacteraemia isolates were broadly comparable to equivalent PHE data.  

**Figure 10: Proportions of *K. pneumoniae* bacteraemia isolates non-susceptible to commonly used antibiotics, 2013 to 2017.**
**Klebsiella oxytoca**

In 2017, 205 cases of *K. oxytoca* bacteraemia, an incidence of 3.8 per 100,000 population, were observed; with the rate remaining stable over the last five years (Figure 8).

**Susceptibility of *K. oxytoca***

Susceptibility among *K. oxytoca* bacteraemia isolates has remained relatively stable over the last five years (Figure 11). Isolates were typically susceptible to all tested agents. All isolates were susceptible to meropenem. Susceptibility trends were broadly comparable to equivalent PHE data.\(^7\)

Figure 11: Proportions of *K. oxytoca* bacteraemia isolates non-susceptible to commonly used antibiotics, 2013 to 2017.
**Pseudomonas aeruginosa**

In 2017, 271 cases of *P. aeruginosa* bacteraemia, an incidence of 5.0 per 100,000 population were reported; this rate has remained stable over the last five years (Figure 8).

**Susceptibility of *P. aeruginosa***

*P. aeruginosa* is intrinsically resistant to a broad range of antibiotics and any additional acquired resistance limits treatment options. Antibiotics that typically remain susceptible include ceftazidime, ciprofloxacin, gentamicin, meropenem and piperacillin/tazobactam. Non-susceptibility to these agents has remained relatively stable over the last five years (Figure 12). Susceptibility trends were broadly comparable to equivalent PHE data.

Figure 12: Proportions of *P. aeruginosa* bacteraemia isolates non-susceptible to commonly used antibiotics, 2013 to 2017.
**Acinetobacter spp.**

In 2017, 91 cases of *Acinetobacter* spp. bacteraemia an incidence of 1.7 per 100,000 population were reported; this rate has remained stable over the last five years (Figure 8).

**Susceptibility of *Acinetobacter* spp.**

*Acinetobacter* spp. are recognised as being intrinsically resistant to various antibiotics and for their ability to acquire genes encoding resistance determinants.\(^9,10\)

The proportion of *Acinetobacter* spp. bacteraemia isolates non-susceptible to commonly used antibiotics has remained relatively stable over the past five years (Figure 13). In 2017, 35.5% of isolates were non-susceptible to ceftazidime and 28.3% were non-susceptible to piperacillin/tazobactam.

**Figure 13: Proportions of *Acinetobacter* spp. bacteraemia isolates non-susceptible to commonly used antibiotics, 2013 to 2017.**

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*Acinetobacter* spp. bacteraemia isolates were typically susceptible to other tested agents (ciprofloxacin, gentamicin and meropenem). PHE reports non-susceptibility for *Acinetobacter baumannii/calcoaceticus* and *Acinetobacter iwoffii* bacteraemia isolates separately; therefore a direct comparison to these data is not possible.\(^11\)

"The work to protect the effectiveness of antibiotics in recent years has started to take effect, as shown in this report. The continued reduction in antibiotic use is an encouraging sign that the importance of antibiotics is now recognised by clinicians and patients alike. The ongoing surveillance of antibiotic resistant organisms is important in recognising, at an early stage, areas which we need to focus on in the fight against resistance. It is reassuring that we have not seen any significant changes in resistance to antibiotics in the common organisms that cause the majority of infections. Despite these achievements, the challenge to keep our antibiotics effective for the benefit of patients today and in the future remains."

Professor Alistair Leanord, Director of Scottish Microbiology Reference Laboratories, Glasgow.
### Key points

- *E. coli* were the most common cause of bacteraemia in 2017
- The incidence of *E. coli* bacteraemia has increased over the period 2013-2017, but there has been no change over the last year
- The proportions of *E. coli* bacteraemia isolates non-susceptible to commonly used antibiotics were generally stable over the last five years; however, resistance to some antibiotics was consistently high over this period. This is broadly comparable across the UK
- The incidences of other Gram-negative bacteraemias included in this report have remained stable over the last five years
- The proportions of other Gram-negative bacteraemia isolates, included in this report, non-susceptible to commonly used antibiotics were generally stable over the last five years. This is broadly comparable across the UK.

### Measures to prevent and control

In the last year, HPS, along with stakeholders, have been involved in a number of developments, these include:

- The *E. coli* bacteraemia enhanced dashboard has now been launched on NSS Discovery, an NHS information system that enables NHS boards to identify and investigate exceedences. This information can highlight areas for improvement and target the implementation of quality improvement and preventative measures locally and nationally.
- Gram-negative bacteraemia surveillance informs strategic planning, provides targeted interventions and develops quality improvement initiatives.
- Health Protection Scotland (HPS) will work in collaboration with NHS laboratories to gain further intelligence in relation to historical trends.
- Measures to reduce the risk of infection applicable to community and hospital settings reduce the risk of all infections in all care settings.
- The Health and Social Care Integration agenda and the 2020 vision for healthcare delivery in Scotland aim to integrate health and social care with a focus on prevention and supported self management. A system-wide approach has the potential to reduce community acquired infections and associated prescribing; the risk of AMR; reduce the need for hospital admission for infections and reduce the risk of patients developing a severe infection.
- A four nations AMR action plan is being developed to support reductions in *E. coli* bacteraemia.
- A national driver diagram and improvement resource to support development of targeted interventions to support a reduction in Gram-negative bloodstream infections.
Urinary Tract Infections

An important aspect of reducing the incidence of Gram-negative bacteraemia is the prevention and management of primary infections, including urinary tract infections (UTIs). As prescribing for UTIs is usually empirical, it is essential that resistance to commonly used antibiotics is monitored and reported to inform prescribing policy.

The majority of UTIs in Scotland are caused by *E. coli*. In 2017, there were 122,569 *E. coli* urinary isolates reported, compared with 127,935 in 2016. The annual incidence of *E. coli* urinary isolates in 2017 was 2,259 per 100,000 population, a 4.5% decrease on the previous year (p<0.001) (Figure 14). Note bias can occur in this dataset as urine samples tend to be obtained more frequently from patients with failed empirical treatment.

**Figure 14: Incidence (per 100,000 population) of *E. coli* urinary isolates, 2013 to 2017.**

Susceptibility of *E. coli* urinary isolates

Non-susceptibility of *E. coli* urinary isolates to the majority of commonly used antibiotics has decreased over the last five years (Figure 15).

**Figure 15: Proportions of *E. coli* urinary isolates non-susceptible to commonly used antibiotics, 2013 to 2017.**
Exceptions to this include non-susceptibility to ciprofloxacin and gentamicin; to which there were no clear trends observed over the last five years, however there was an increase observed between 2016 and 2017 (11.0% and 9.7% respectively, p<0.001).

In 2017, 55.8% of isolates were non-susceptible to amoxicillin (no clear trend observed over the last five years, however there was a 2.8% decrease over the last year, p<0.001), 38.6% were non-susceptible to trimethoprim (no change over the last five years) and 23.2% were non-susceptible to co-amoxiclav (no clear trend observed over the last five years, however there was a 6.0% decrease over the last year, p<0.001). *E. coli* urinary isolates were typically susceptible to most other tested agents, including nitrofurantoin (12.4% year on year decrease over the last five years, p<0.001).

### Key points

- The majority of reported UTIs were caused by *E. coli*
- Non-susceptibility in *E. coli* isolates has generally decreased over the last five years.

### Measures to prevent and control

- Monitoring and reporting of isolates frequently implicated in UTIs and their resistance characteristics; enhanced surveillance where required.
- In addition, the Urinary Catheter Care Passport is a personal patient record for catheter care, which provides information on prevention of UTIs among patients with indwelling urinary catheters.

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**The Scottish UTI Network (SUTIN) was established in Scotland specifically to target the reduction of UTIs. SUTIN launched the National Hydration Campaign in 2017, with the key aim to encourage good hydration and thus reduce the risk of developing a UTI.**

![Healthy pee chart](chart.png)

**URINARY CATHETER CARE PASSPORT**

This is a person held record. Please take this booklet with you to all healthcare appointments.

**Issued October 2017**
Carbapenemase-producing organisms

Carbapenems are very broad-spectrum antibiotics which are used almost exclusively in the hospital setting for the treatment of suspected or confirmed multi-drug resistant Gram-negative infections.

The emergence of carbapenemase-producing organisms (CPOs) is of particular concern as enzymes produced by these organisms can inactivate carbapenem antibiotics, leaving few therapeutic options for treatment of CPO infections. CPOs have been reported worldwide in healthcare and community settings, with increased global travel, particularly exposure to healthcare abroad, contributing to their spread.14-16

CPO isolates included in this report are derived from a range of screening and clinical specimens including urine, respiratory and blood samples. A total of 108 CPO isolates were reported from the Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit, PHE and the Scottish AMR Satellite Laboratory, in 2017, compared with 73 isolates reported in 2016 (Figure 16). Reporting of CPO isolates in Scotland began in 2003.

Figure 16: Number of CPO isolates (all body sites) by enzyme type reported in Scotland by AMRHAI (PHE) and the Scottish AMR Satellite Laboratory, 2003 to 2017.

![Figure 16](image)

Of the CPOs identified in 2017, 93.5% were carbapenemase producing Enterobacteriaceae (CPE). The most frequently isolated enzyme was OXA-48 (oxacillinase) like enzymes (34.3%) followed by NDM (New Delhi Metallo-beta-lactamase) (27.8%) and VIM (Verona Integron-encoded Metallo-beta-lactamase) (16.7%) (Figure 16).

There was a year on year increase (39.3%, p<0.001) in the incidence of CPO isolates over the last five years, from 0.4 per 100,000 population in 2013 to 2.0 per 100,000 population in 2017 (Figure 17).

This increase in incidence is likely due to an increase in the number of NHS boards implementing screening for CPE. This is a result of a number of initiatives that have been introduced in the last few years including a toolkit for the early detection, management and control of CPE in both acute and non-acute settings.17,18 While the number of CPE isolates reported in Scotland has increased in recent years, it remains low compared with that for the rest of the UK.19
In conclusion, as carbapenem antibiotics are preserved for the treatment of multi-drug resistant infections, increasing incidence of carbapenem-resistant organisms presents the potential for infections which cannot be treated effectively. Alternative treatment regimens need to be considered and are limited to either combination therapy or utilisation of older antibiotics with lower efficacy such as colistin.

**Key points:**

- The number of CPOs isolated in Scotland is low relative to other countries; however, these have been increasing over recent years
- This increase is likely the result of an increase in the number of NHS boards implementing CPE screening; 44.4% of CPOs were taken from screening samples in 2017 compared with 19% in 2015
- 93.5% of CPOs in 2017 were CPEs
- The most frequently isolated enzymes were OXA-48, NDM and VIM.

**Measures to prevent and control:**

- Screening for multi-drug resistant organisms (MDRO) on admission to hospital is a key intervention which can reduce the opportunities for infections to develop and spread in healthcare settings.
- Early detection of high-risk patients using a clinical risk assessment (CRA) based approach, allows pre-emptive isolation of patients carrying these organisms while microbiological results are awaited, reducing the opportunity for transmission if a patient is colonised or infected.
- In April 2018, the national monitoring tool for the meticillin resistant *Staphylococcus aureus* (MRSA) screening Key Performance Indicator (KPI) was expanded to include a CPE module. This redeveloped MDRO acute admission screening tool system will monitor the uptake of the CRA for both MRSA and CPE, which are analysed and fed back to NHS boards on a quarterly basis.
- An educational electronic module on HAI screening (covering both CPE and MRSA) for all staff was launched in January 2017 and can be accessed via the following link: [https://www.nes.scot.nhs.uk/education-and-training/by-theme-initiative/healthcare-associated-infections/online-short-courses/hai-acute-hospital-admission-screening.aspx](https://www.nes.scot.nhs.uk/education-and-training/by-theme-initiative/healthcare-associated-infections/online-short-courses/hai-acute-hospital-admission-screening.aspx).
- The prudent use of antibiotics including promoting the use of carbapenem sparing antibiotics is essential.
**Enterococcus spp. bacteraemia**

Enterococcus spp. are recognised as causing a number of healthcare associated infections (HCAIs), including bacteraemia and UTI. The majority of enterococcal infections are caused by *Enterococcus faecalis* and *Enterococcus faecium*.  

In 2017, 474 cases of *E. faecalis* bacteraemia and 308 cases of *E. faecium* bacteraemia were reported. The incidence of *E. faecalis* bacteraemia (8.7 per 100,000 population) and *E. faecium* bacteraemia (5.7 per 100,000 population) has remained stable since 2013 (Figure 18).

**Figure 18: Incidence rates (per 100,000 population) of *E. faecalis* and *E. faecium* bacteraemia, 2013 to 2017.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidence rate per 100,000 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>8.0</td>
</tr>
<tr>
<td>2014</td>
<td>7.0</td>
</tr>
<tr>
<td>2015</td>
<td>6.0</td>
</tr>
<tr>
<td>2016</td>
<td>5.0</td>
</tr>
<tr>
<td>2017</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Susceptibility of Enterococcus spp.**

Enterococci exhibit intrinsic resistance to a broad range of antibiotics, particularly *E. faecium*; which limits treatment options. Of particular concern is resistance to glycopeptide antibiotics, such as vancomycin. The percentage of *E. faecium* bacteraemia isolates non-susceptible to vancomycin in 2017 was 40.8% (Figure 19). A 26.9% year on year increase over the last five years (p<0.001) has been observed. There were no isolates of *E. faecalis* non-susceptible to vancomycin.

**Figure 19: Percentages of *E. faecium* bacteraemia isolates non-susceptible to vancomycin, 2013 to 2017.**
The most recent European Centre for Disease Prevention and Control (ECDC) AMR report shows that in the European Union (EU)/European Economic Area (EEA) in 2016, only Romania (39.0%), Ireland (44.1%) and Cyprus (46.3%) reported higher vancomycin resistance proportions in *E. faecium* bacteraemia than Scotland (35.9% in 2016).\(^2\) PHE ‘Surveillance of *Enterococcus* spp. causing bacteraemia in England, Wales and Northern Ireland: 2016’, reported a steady increase in the proportion of vancomycin resistant *E. faecium* bacteraemia isolates from 2012 to 2015 (20% to 26%) with a decrease to 23% seen in 2016.\(^2\)

Linezolid and tigecycline are used to treat vancomycin resistant strains of enterococci. The emergence of resistance to these antibiotics is of concern as it limits available treatment options. In Scotland, in 2017 there was one *E. faecium* bacteraemia isolate non-susceptible to vancomycin and linezolid and a separate *E. faecium* bacteraemia isolate non-susceptible to vancomycin and tigecycline. No *E. faecalis* bacteraemia isolates were non-susceptible to vancomycin, linezolid or tigecycline.

### Key points

<table>
<thead>
<tr>
<th>The incidence of <em>E. faecium</em> and <em>E. faecalis</em> bacteraemia has remained stable over the last five years, with the overall numbers of enterococcal bacteraemia remaining low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whilst the burden of enterococcal bacteraemia remains low, the proportion of vancomycin resistant <em>E. faecium</em> bacteraemia continues to increase, adding to the overall burden of AMR.</td>
</tr>
</tbody>
</table>

### Measures to prevent and control:

- Monitoring and reporting of enterococcal isolates and their resistance characteristics.
- HPS is undertaking an epidemiological analysis including data linkage to better understand the risk factors associated with, and the morbidity and mortality attributable to, vancomycin resistant *E. faecium* bacteraemia in Scotland.
- Promotion of application of standard and transmission based infection control precautions.

> “The ongoing high proportion of glycopeptide resistant *E. faecium* isolates reminds us that we need to remain vigilant for resistance in Gram-positive as well as Gram-negative organisms. Although the total number of isolates is low, we hope that our ongoing epidemiological analysis may help us better understand the related risk factors.”

Dr. Michael Lockhart, Consultant Medical Microbiologist, Health Protection Scotland (HPS)
Neisseria gonorrhoeae

In Scotland, in 2017, 2,610 episodes of N. gonorrhoeae infection, an incidence of 73.6 per 100,000 population, were reported (Figure 20). The Scottish Bacterial Sexually Transmitted Infections Reference Laboratory (SBSTIRL) performs gonococcal antibiotic surveillance in Scotland (GASS) and the annual report is published on the HPS website. The reference laboratory tests all N. gonorrhoeae isolates for sensitivity to seven antibiotics. Of 1,338 episodes of gonococcal infection isolates tested in 2017, 49% were resistant to one or more antibiotics, this is higher than the 42% observed in 2016 and comparable to the 50% reported in 2015 (Appendix).

A dual antibiotic regimen is currently recommended consisting of ceftriaxone and azithromycin. No isolates with decreased susceptibility to ceftriaxone were recorded. Of note, however, is the emergence of decreased susceptibility to azithromycin in 3.4% (46) of isolates, and of these, 21 which demonstrated high level azithromycin resistance (HL-AziR). This corresponds to 1.6% of all isolates. However, as these isolates were sensitive to ceftriaxone, affected individuals could be treated successfully. Further details are available in the GASS report.

Figure 20: Episodes of N. gonorrhoeae by gender, 2013 to 2017.

Key points including measures to prevent and control:

- Currently in Scotland, the number of gonorrhoea infections highly resistant to azithromycin, part of the current treatment regime, is low but increased from between 0.0-0.2% during the previous five years to 1.6% in 2017.
- In response to this observation, Scotland has established a short life working group to further investigate and to consider if any change to recommended clinical practice, including the optimal antibiotic treatment regimen for gonorrhoea, is required.
- The British Association for Sexual Health and human immunodeficiency virus (HIV) (BASHH) are proposing alternative treatment regimes in draft guidelines which are at consultation stage.
- It is essential that monitoring continues and all isolates are sent to the SBSTIRL for resistance testing to help guide the choice of effective treatment.
- While prevention of infection is the primary goal, effective partner notification along with a post treatment test (or test of cure) to determine the efficacy of treatment, play a key role in reducing the transmission of infection.
**Mycoplasma genitalium**

*Mycoplasma genitalium* is an emerging cause of sexually transmitted infection (STI) of interest. Infection with *M. genitalium* causes symptoms similar to other STIs notably chlamydia and gonorrhoea, with pain on urination in men and inflammation of the cervix in women. Infected individuals sometimes have no symptoms. Untreated infection can lead to reproductive complications including pelvic inflammatory disease (PID) in women.

The prevalence in the UK general population is available from the third National Survey of Sexual Attitudes and Lifestyles (NATSAL-3). Using a stratified probability sample survey a population prevalence of 1% in both men and women aged 16-44 years was observed. This proportion is higher among those attending specialist sexual health clinics (ranging from 4-38%). Antibiotic resistance is well established with high levels (up to 40%) of macrolide resistance reported.

### Key points including measures to prevent and control:

- *Mycoplasma genitalium* is now being recognised as an important treatable STI
- Antibiotic resistance is well established with high levels of macrolide resistance reported
- An expert group was convened in May 2018 to address testing and treatment of *M. genitalium* in Scotland
- Further, BASHH has published new treatment guidelines (accredited by the National Institute for Health and Care Excellence (NICE)) to help reduce the likelihood of *M. genitalium* becoming highly resistant to a number of first and second line antibiotics. At the time of writing, the guideline is in draft form awaiting the result of the consultation process
- A Polymerase Chain Reaction (PCR) testing service for the whole of Scotland has been established, by Molecular Microbiology, NHS Lothian. The test is available to those eligible as defined by certain criteria and these include symptomatic individuals who test negative for *N. gonorrhoeae* and *Chlamydia trachomatis* and/or who remain symptomatic despite antibiotic treatment. Testing for macrolide and fluoroquinolone resistance by Sanger sequencing is also performed by the SBSTIRL
- High levels of macrolide resistance in *M. genitalium* mean that effective treatment is important; there are overlaps with treatment of chlamydial and gonococcal infection and thus, challenges to good antibiotic stewardship arise when individuals are receiving doses of antibiotics for other STIs
- It is important that resistance monitoring takes place, alongside relevant testing and diagnosis, to advise on appropriate treatment regimes
- In addition, follow up of all sexual partners and a test of cure are recommended to ensure that all individuals who are receiving treatment are monitored for their response to treatment.

“Surveillance of antibiotic resistance to STIs, alongside effective follow up of sexual partners, is essential for guiding optimal treatment choices and providing the best care for our patients”

Dr. Kate Templeton, Director of Scottish Bacterial Sexually Transmitted Infections Reference Laboratory, Edinburgh
Invasive fungal infections and antifungal use

Invasive fungal infections have grown in importance in modern healthcare, in part due to the increasing at-risk immunocompromised population. The most common fungal pathogens causing invasive infection in the UK are *Candida* and *Aspergillus* spp.\textsuperscript{26-28} In particular, *Candida* spp. are important pathogens causing bloodstream infections (candidaemia) in healthcare settings, with high reported morbidity and mortality rates.\textsuperscript{27,29-32} In addition, candidaemia is associated with prolonged hospitalisation, resulting in substantially increased healthcare costs.\textsuperscript{29}

In acute hospitals triazoles and echinocandins are the main antifungals used in the prevention and treatment of invasive fungal disease. In 2017, triazoles accounted for 75.6% of antifungal use in acute hospitals, with echinocandins accounting for 5.3%. The use of triazoles in acute hospitals in 2017 was 8.6% lower (p<0.001) compared to 2013, whereas use of echinocandins increased by 24.5% (p<0.001) over the same period (Figure 21).

**Figure 21: Use of triazoles and echinocandins in acute hospitals, DDD/1,000/OBDs, 2013 to 2017.**

![Graph showing use of triazoles and echinocandins in acute hospitals, 2013-2017.](image)

The antimicrobial stewardship programme in Scotland has historically focussed on the use of antibiotics but with the increasing importance of candidaemia and other invasive fungal infections together with the threat from antifungal resistance, the SAPG has established an antifungal stewardship subgroup. The initial focus has been to optimise antifungal use for prevention and treatment of invasive fungal disease in haematology/oncology, intensive therapy units (ITU) and following surgery, and in patients with respiratory infections. The group is developing best practice guidelines on the use of antifungals in these areas and national consensus on using diagnostics to avoid unnecessary antifungal use.
Candidaemia

The number of cases of candidaemia has remained relatively stable since 2013 (Table 2).

Table 2: Number of candidaemia cases by most common species (2013 to 2017).

<table>
<thead>
<tr>
<th></th>
<th>C. albicans</th>
<th>C. glabrata</th>
<th>C. parapsilosis</th>
<th>C. tropicalis</th>
<th>Other species*</th>
<th>All Candida spp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>120</td>
<td>77</td>
<td>34</td>
<td>12</td>
<td>35</td>
<td>278</td>
</tr>
<tr>
<td>2014</td>
<td>96</td>
<td>70</td>
<td>23</td>
<td>9</td>
<td>36</td>
<td>234</td>
</tr>
<tr>
<td>2015</td>
<td>135</td>
<td>81</td>
<td>31</td>
<td>10</td>
<td>23</td>
<td>280</td>
</tr>
<tr>
<td>2016</td>
<td>98</td>
<td>85</td>
<td>28</td>
<td>5</td>
<td>29</td>
<td>245</td>
</tr>
<tr>
<td>2017</td>
<td>120</td>
<td>67</td>
<td>49</td>
<td>8</td>
<td>31</td>
<td>275</td>
</tr>
<tr>
<td>Total</td>
<td>569</td>
<td>380</td>
<td>165</td>
<td>44</td>
<td>154</td>
<td>1312</td>
</tr>
</tbody>
</table>


During 2017, there were 275 cases of candidaemia, compared with 245 in 2016. The annual incidence was 5.1 (per 100,000 population), which is comparable to rates since 2013 (Figure 22).

The incidence of candidaemia in Scotland was comparable to that reported for the rest of the UK. The rate of candidaemia per 100,000 was 5.1 in Scotland compared with 3.5 in England, 5.1 in Northern Ireland, and 5.2 in Wales.33

Antifungal susceptibility of Candida species

Antifungal use is associated with the development of antifungal resistance, with multi-drug resistance being of particular concern. In terms of common Candida spp; C. albicans isolates are typically sensitive to most antifungal agents, whilst C. glabrata isolates may exhibit decreased susceptibility to certain antifungals, in particular triazoles (e.g. fluconazole and voriconazole).27,28,31
Non-susceptibility of candidaemia isolates to commonly used antifungals has been broadly stable since 2013 ([Appendix](#)). Note *C. tropicalis* has not been included due to small numbers.

Of note, non-susceptibility of *C. glabrata* isolates to fluconazole is 76.2% in Scotland versus 42.3% in England (as an average from 2015-2017). Two methods for the interpretation of susceptibility results are used variably in laboratories in both Scotland and the rest of the UK; Clinical and Laboratory Standards Institute (CLSI) and European Committee on Antimicrobial Susceptibility Testing (EUCAST), breakpoints of which vary for fluconazole. One of these methods outlines a category for isolates which are considered to be susceptible dose dependent (SDD). As it is not possible to differentiate between use of these methods, fluconazole non-susceptibility results for *C. albicans* and *C. glabrata* need to be interpreted with caution.

Generally, antifungal resistance in *Candida* species is relatively uncommon. Work to standardise susceptibility testing and reporting is currently underway in Scotland and the rest of the UK.

**Candida auris**

Additionally, the identification and emergence of *C. auris* as a highly resistant species, associated with multiple outbreaks globally, is a further public health issue.\(^{34}\)

Isolates of *C. auris* identified in the UK have been relatively susceptible, although all have been fluconazole resistant. There have been three large outbreaks of *C. auris* in intensive care settings in England and it is considered that the apparent high transmissibility associated with the species is partly responsible.\(^{19,33}\) In 2017, PHE produced guidance for the laboratory investigation, management and infection prevention and control for cases of *C. auris*,\(^ {35}\) which was endorsed for use in Scotland in 2018.

Whilst no cases of *C. auris* have been reported in Scotland, it is important to continue to monitor the situation.

> "Advances in medical technology over the past two decades have led to the emergence of Candida spp. as a significant cause of invasive disease. Despite better understanding of risk factors and developments in infection prevention and treatment, candidaemia continued to cause morbidity and mortality with crude mortality rates of up to 50% reported. It is important to continue to monitor emerging resistance among fungal infections."

Dr. Brian Jones,
Consultant Medical Microbiologist NHS Greater Glasgow and Clyde
Chair of SAPG antifungal stewardship subgroup

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Scottish One Health Antimicrobial Use and Antimicrobial Resistance Annual Report 2017
Key points

- In acute hospitals triazoles and echinocandins are the main antifungals used in the prevention and treatment of invasive fungal disease.
- In acute hospitals triazoles accounted for 75.6% of antifungal use in 2017 and echinocandins accounted for 5.3%.
- Use of triazoles in 2017 was 8.6% lower compared to 2013 whereas use of echinocandins increased by 24.5% over the same period.
- The antimicrobial stewardship programme has been extended to include work to optimise the use of antifungals.
- The rate of candidaemia has remained relatively stable over the last five years. This is comparable to rates reported across the UK.
- Non-susceptibility of candidaemia isolates to common antifungals has also remained stable over the last five years.
- There is variation in the methods used for interpretation of susceptibility results across the UK. In particular; fluconazole non-susceptibility data for *C. albicans* and *C. glabrata* needs to be interpreted with caution.

Measures to prevent and control

- With the aim of rationalising prescribing of antifungals; the SAPG Antifungal Subgroup is currently working to develop best practice guidance on empirical treatment and prophylactic use of antifungals in high risk patients.
- The SMVN AST Subgroup will form an antifungal short life working group to investigate how laboratory testing and reporting vary across NHSScotland with a view to improve standardisation. This will enable a better understanding, and guide approaches, to prevention and control.
- In early 2018, the PHE ‘Guidance for the laboratory investigation, management and infection prevention and control for cases of Candida auris’ was approved for use in Scotland by the Scottish Health Protection Network (SHPN). An additional addendum to this guidance was also endorsed.
Human and animal non-typhoidal *Salmonella*

The surveillance of human *Salmonella* in Scotland relies on reports from the Scottish *Salmonella, Shigella and Clostridioides difficile* Reference Laboratory (SSSCDRL) which receives isolates from all diagnostic microbiology laboratories. In addition, SSSCDRL receives animal and food isolates for identification and typing, thus provides a valuable opportunity for the surveillance of all isolates.

**Human**

In the late 1990s mass poultry vaccination programmes were introduced to combat *Salmonella* infections, resulting in a significant decline in the number of human cases reported, particularly *Salmonella Enteritidis* phage type (PT) 4.

**Figure 23: *Salmonella* in human laboratory confirmed reports 1990 to 2017.**

In 2017, there were 840 reported cases of *Salmonella* with the number of cases remaining stable over the last five years. *S. Enteritidis* and *Salmonella Typhimurium* were the most commonly reported serotypes accounting for 51% of cases. This figure is comparable with previous years; between 2012 and 2016 around 55% of cases were represented by these two serotypes.

Annually, around 30% of cases of *Salmonella* reported are believed to have been acquired abroad. In 2017, 29.5% of cases were believed to have acquired their infection abroad. This figure, however, is an underestimate as HPS does not receive travel histories for all cases.

**Susceptibility of human non-typhoidal *Salmonella***

Overall, in 2017, 56.2% of isolates were fully sensitive to all antibiotics tested (Appendix). Non-susceptibility was high for the following antibiotics: sulphamethoxazole (25.4%), tetracycline (23.9%), ampicillin (21.3%), low level (<0.125mg/L) ciprofloxacin (21.4%) and nalidixic acid (19.8%) (Figure 24). Non-susceptibility to all antibiotics has remained relatively stable over the last five years.
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* subtypes in the sample set for each reporting period.

**Animal**

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 SSSCDRL. No information on prior antibiotic treatment is available for *Salmonella* isolates identified from animal samples. *Salmonella* isolates are tested for susceptibility to the same 15 antibiotic agents of veterinary and human health significance ([Appendix](#)). 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. 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 often be part of the treatment regimen instituted by an attending veterinarian. Vaccines against some serotypes of *Salmonella* 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.

The number of reports of *Salmonella* in animals has remained relatively stable over the last five years with 233 recorded in 2017 (compared to 245 and 207 reported in 2016 and 2015 respectively) (Figure 25).
The majority of reports were from cattle (54.1%), sheep (19.3%) and pigs (15.9%). The remaining reports were from a variety of animals including dogs, cats and reptiles.

**Susceptibility of animal non-typhoidal *Salmonella***

In 2017, 72.1% (233) of *Salmonella* reported from animals were fully sensitive to all antibiotics against which they were tested ([Appendix](#)). This is comparable to that observed in previous years. Non-susceptibility was high for sulphonamide (23.6%), ampicillin (22.7%) and tetracycline (20.6%). Non-susceptibility to all antibiotics has remained relatively stable over the last five years, except for year on year increases for chloramphenicol (29.6%, p=0.001) and spectinomycin (21.5%, p=0.006).

<table>
<thead>
<tr>
<th>Key points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of reported cases of human <em>Salmonella</em> has remained stable over the last five years</td>
</tr>
<tr>
<td>The proportions of human <em>Salmonella</em> isolates non-susceptible to commonly used antibiotics were generally stable over the last five years; however, non-susceptibility to some antibiotics was consistently high over this period</td>
</tr>
<tr>
<td>The number of reports of <em>Salmonella</em> in animals has remained relatively stable over the last five years</td>
</tr>
<tr>
<td>Non-susceptibility to all antibiotics has remained relatively stable over the last five years, except for year on year increases in a few antibiotics.</td>
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</tbody>
</table>
Antimicrobial Resistance in Animals

Antimicrobial resistance in veterinary clinical isolates

This is the second year that collated data on resistance in veterinary clinical isolates from Scotland have been reported in this way. Knowledge on antimicrobial resistance in bacterial isolates from animals with disease is necessary to understand more fully the epidemiology of resistance in a ‘One Health’ context.

These data derive from clinical specimens submitted to the farm and companion animal diagnostic services offered by Scotland’s Rural College (SRUC) Veterinary Services and Capital Diagnostics.

In contrast to the human data presented in this report:

- These samples are tested on a ‘charged for’ basis to inform private veterinary treatment of diseased animals
- Therefore, there are additional biases, essentially cost to the animal keeper, that affect the submission of samples to this service
- The primary purpose of screening for antimicrobial resistance is to inform veterinary treatment and they are tested using British Society for Antimicrobial Chemotherapy (BSAC) disc diffusion methodology against a panel of antibiotics relevant for that purpose at, where they exist, species-relevant clinical breakpoints. Bacteriology is accredited by UK Accreditation Service (UKAS) to International Organization for Standardization (ISO) 17025
- Interpretation of these data in terms of their relevance to public health is difficult beyond the notion of evidence of impact of a selection pressure being applied in another compartment of the ecosystem. The 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 organisms that cause morbidity in people.

In 2017, there were 2,559 veterinary clinical isolates reported. Isolates were from a number of different species, 35.4% (906) were from canines, 26.5% (679) were from bovines, 11.4% (292) were from ovine, 10.0% (256) were from broilers, and the remaining 16.6% (426) were from 31 different species. There were 130 different organisms isolated.

Selected organisms

Staphylococcus spp.

Staphylococcus spp. are common commensal organisms that act as important pathogens of livestock and companion animal species. The sensitivity patterns for selected Staphylococcus spp for 2013 to 2017 are shown in the Appendix. Non-susceptibility remains high for S. aureus and Staphylococcus pseudintermedius isolates from companion animals for several antibiotics, in particular to ampicillin (S. aureus (14, 66.7%), S. pseudintermedius (45, 78.9%)) and the topical agent fusidic acid (S. aureus (6, 33.3%), S. pseudintermedius (24, 24.6%)). High non-susceptibility to fusidic acid is of concern given it is a recommended and commonly used antibiotic for the management of S. pseudintermedius associated otitis externa. Non-susceptibility to first generation cephalosporins and the widely used co-amoxiclav remains low. For Staphylococcus spp from livestock, non-susceptibility was generally unchanged in 2017 and remained low for the majority of antibiotics.
In 2017, meticillin resistance was identified in 12/172 (7.0%) of *S. aureus* isolates tested, 12/108 (11.1%) *S. pseudintermedius* isolates, 1/17 (5.9%) *S. schleiferi* isolates and 1/1 (100%) *S. epidermidis* isolate. Comparison with previous years is difficult due to low numbers assessed previously. The findings for 2017 are notable given that all the *S. pseudintermedius* isolates are from companion animals which have close contact with their owners.

**Streptococcus spp.**

*Streptococcus* spp. are important pathogens of livestock and companion animal species, with the potential to cause severe disease of the skin, ear, respiratory tract, body cavities, wounds and urinary tract.
The sensitivity patterns for selected *Streptococcus* spp. for 2013 to 2017 are shown in [Appendix](#). Generally, the non-susceptibility in companion animal and equine isolates are similar in 2017 compared to previous years. It is notable that non-susceptibility to lincomycin is high in isolates from livestock animals (34.2%, 13/38), the explanation for which is unclear. There was no evidence of non-susceptibility to penicillin among *Streptococcus* spp.

**Pasteurellaceae**

Pasteurellaceae are important causes of potentially severe respiratory and soft tissue infections in companion and livestock animals. In livestock animals, severe morbidity and mortality can result with consequential significant economic losses. Important bacterial species included in this report are *Pasteurella multocida* (companion animals, cattle, and sheep), *Mannheimia haemolytica* (cattle, sheep), *Bibersteinia trehalosi* (cattle, sheep) and *Actinobacillus pleuropneumoniae* (pigs). Of these, *P. multocida* can cause severe disease in humans, but the others have no known zoonotic potential for humans.

The sensitivity patterns for the selected Pasteurellaceae for 2017 from companion and livestock animals are generally similar to previous years ([Appendix](#)). However, since 2013 there has been a year on year increase observed (183.1%, p=0.01) in non-susceptibility in *B. trehalosi* to florfenicol, which is commonly used in the management of this infection.

**K. pneumoniae**

*K. pneumoniae* is a cause of significant economic loss to the livestock industry, and is a potential zoonotic agent. The sensitivity patterns for *K. pneumoniae* for 2013 to 2017 are shown in [Appendix](#). Non-susceptibility is similar to previous years with low non-susceptibility observed for spectinomycin, trimethoprim-sulphonamide, co-amoxiclav and enrofloxacin. Spectinomycin remains the recommended treatment for *K. pneumoniae*.

**Corynebacterium spp.**

*Corynebacterium* spp. are associated with serious soft tissue infections and otitis externa in the dog (*Corynebacterium auriscanis*) but invasive corynebacteriosis in companion animals remains rare. *Corynebacterium* spp. are also associated with soft tissue infections in livestock. The sensitivity patterns for *Corynebacterium* spp. for 2013 to 2017 are shown in the [Appendix](#). Non-susceptibility continues to be high across a wide spectrum of systemically administered antibiotics.

**E. coli isolates from healthy animals**

**Descriptive epidemiology**

*E. coli* are a major constituent of the normal faecal flora of humans and warm-blooded animals, however, some strains can cause both intestinal and extra-intestinal disease. In addition to isolates from infectious disease, *E. coli* collected from enteric samples of healthy animals are tested as a measure of the background resistance in livestock. In previous years, the latter was achieved by sampling faeces of cattle and sheep submitted to veterinary laboratories for parasitology monitoring. From June 2017, a pilot project was established to estimate and monitor prevalence of resistance in *E. coli* cultured from livestock presenting at abattoirs, which included pigs and poultry for the first time. As with the previous year, isolates from healthy animals were tested with antibiotics of particular relevance to human treatment, whereas those from animals with active infections were tested for compounds relevant to veterinary practice.
In samples collected from animals entering the food chain, the levels of non-susceptibility in *E. coli* from poultry and pigs were greater than those detected from cattle and sheep (Figure 28). In all four hosts, the highest levels of non-susceptibility amongst the twelve antibiotics tested were for ampicillin and tetracycline; both of these compounds are amongst the antibiotics used most frequently for treatment of infections in livestock. Notable levels of non-susceptibility for a single host were evident for gentamicin in poultry and chloramphenicol (an antibiotic which is not licenced for use in food animals) in pigs. Non-susceptibility to carbapenems was not detected in any samples, while non-susceptibility to third generation cephalosporins was only detected in two samples, both AmpC producing isolates from pigs.

“I am really delighted to see the publication of the second SONAAR report bringing together intelligence on AMU and AMR in Scotland’s ecosystem from increasingly rich and diverse surveillance activities. Widespread recognition and acceptance of AMR as a quintessential One Health problem has given great impetus to unprecedented closely aligned collaborative initiatives among health care and other sectors. It is essential in the coming years to continue to add both depth and breadth to the intelligence that forms the basis of the SONAAR report, so as to appreciate more clearly the causation of AMR at ecosystem level, and to design more precise and effective interventions to mitigate its threat.”

Professor Dominic Mellor, Consultant in Veterinary Public Health and Professor of Epidemiology and Veterinary Public Health at the University of Glasgow

Figure 28: Non-susceptibility of *E. coli* among bovine, ovine, porcine and poultry animals in 2017.
With regard to *E. coli* from diagnostic samples, extended-spectrum beta-lactamases (ESBLs) were detected in an *E. coli* from a faeces sample from a single pig and also from the urine of a dog. In 2016, five ESBLs were detected from animal diagnostic samples.

**Key points and measures to prevent and control**

- Data from veterinary clinical isolates have shown that non-susceptibility has remained stable over the last five years.

- However, it is important that monitoring continues for non-susceptibility of bacteria from animals to contribute to a our understanding of AMR in the ‘One Health’ context.

- Enterobacteriaceae, including *E. coli* and *K. pneumoniae* are a major concern with respect to increasing antimicrobial resistance, especially those producing carbapenemases and extended spectrum $\beta$-lactamases. It is reassuring that neither were found in the healthy animals sampled.

- ESBLs were detected in low numbers from diagnostic isolates. It should be noted that carbapenemases were only tested for in a very small number of Enterobacteriaceae isolates from diagnostic samples.

- Scotland’s Healthy Animals website was formally launched at AgriScot on 15th November 2017, thus providing an important platform for promotion of guidance on disease avoidance and antibiotic stewardship to the wider animal health community.

- Scotland’s Poultry Hub is a ‘go to’ resource that was developed for poultry keepers, especially smallholders, signposting guidance and helpful up-to-date information about keeping poultry healthy so as to avoid the need to treat disease. This resource is hosted on the Scotland’s Healthy Animals website and it is envisaged that this platform will be utilised as a trusted ‘one-stop shop’ of disease avoidance and antimicrobial stewardship information and guidance for all animal keepers and their veterinarians.

- The Scottish Veterinary Antimicrobial Stewardship Group has been established which aims to optimise stewardship and prescribing in veterinary practice by drawing together representation from all veterinary sectors (including pigs, poultry, cattle, sheep, horses, companion animals, exotics, fish and aquaculture) and from veterinary nursing.

- Guidance for Countryside and Leisure users has also been drafted as part of the Scotland’s Healthy Animals website. This offers guidance on responsible countryside access and prevention of spread of infectious diseases throughout the countryside as well as avoiding bringing home agents with the potential to infect people.
Public Health Microbiology

The HPS Public Health Microbiology (PHM) team has been working closely with the Antimicrobial Use and Resistance Team during 2017-18. The core principle of PHM is to facilitate data integration and analysis. This depends on collaborative working of a number of discrete specialties so that infection information and isolated knowledge are integrated to produce epidemic intelligence which will inform public health action and policy (Figure 29).

Figure 29: The elements of Public Health Microbiology.

The functions of PHM are identified in Figure 30. The HPS PHM team has led on the development of a strategy document to develop a plan to deliver these functions. The strategy was consulted on during 2017-18 and recently approved by the SHPN.

Figure 30: Public Health Microbiology Functions.
The benefits of the PHM strategy for the management of AMR in Scotland will be:
1. Consistent data capture from human diagnostic and reference laboratory services. In addition, dependent on further discussions, some non-human laboratory services.
2. Providing early warning of evolving AMR health threats to allow early intervention and minimisation of the impact of these threats.
3. By collaborating with key partners, working towards providing efficient microbiology services across Scotland that are modern, resilient, adaptable and able to provide surge capacity when needed to respond to infectious threats.
4. Should provide a framework to support workforce education for AMR threats.

“The Public Health Microbiology strategy is vital to ensure that we have high quality, standardised data for monitoring infections and their epidemiological, genetic and resistance characteristics so that they can be identified and controlled as soon as possible.”

Dr. Michael Lockhart, Consultant Medical Microbiologist, Health Protection Scotland (HPS)
AMR Alerts

National early warning system for exceptional resistance phenotypes

In addition to national surveillance, it is important to monitor AMR in a timely manner to serve as an early warning system (EWS) for emerging resistant pathogens. This approach facilitates rapid distribution of information about emerging multi-drug resistant pathogens to hospitals and public health authorities, and expedites the implementation of infection control interventions to prevent the emergence or transmission of antimicrobial drug resistant pathogens in health-care facilities and/or the community.\textsuperscript{56,37} The advantage of a national EWS is that emerging resistance including regional trends which may not be apparent at the local board level can be detected.

In the latter part of 2017, HPS and the SMVN AST Subgroup agreed a revised list of exceptional resistance phenotypes based on the EUCAST exceptional phenotype list which can be found in Chapter 3 of the ‘National Infection Prevention Control Manual (NIPCM) Appendix 13’ (http://www.nipcm.scot.nhs.uk). The revised list underpinned the development of an EWS in line with the Strategic Aims and Approach section of the UK Five Year Antimicrobial Resistance Strategy, 2013 to 2018 recommendation to “improve the knowledge and understanding of AMR through better information, intelligence, supporting data and developing more effective early warning systems to improve health security”.

The HPS EWS is based on an IT algorithm that identifies all Scottish diagnostic laboratory reports of exceptional resistance phenotypes received by HPS that are of potential public health concern. This enables prompt action to be taken by the submitting laboratory and facilitates timely investigation to confirm veracity and further characterisation if appropriate. It can also impact on the clinical management of cases and allow appropriate infection control procedures to be implemented.

Figure 31: The steps involved in generating an AMR alert.

“Surveillance of AMR and monitoring antibiotic usage is fundamental to everyday management of patients in clinical practice. An early warning system improves our ability to detect, confirm and promptly manage emerging resistant pathogens thereby reducing morbidity and mortality. This allows us to use the appropriate antibiotics more effectively and prevent transmission of resistant organisms.”

Dr Mairi MacLeod, Scottish Microbiology and Virology Network (SMVN) Antimicrobial Susceptibility Testing (AST) Subgroup Chair, Glasgow Royal Infirmary
European indicators on antibiotic use and resistance

In 2017, the European Commission requested the ECDC, the European Food Safety Authority (EFSA) and the European Medicines Agency (EMA) to jointly establish a list of harmonised outcome indicators for antibiotic use and resistance. These indicators are intended to assist countries across Europe to assess progress in reducing antibiotic use and surveillance of AMR. It was recommended these indicators should be based on a ‘One Health’ approach and wherever possible be based on data already collected through surveillance programme activities.

The selected indicators are divided into primary and secondary indicators. Primary indicators broadly reflect the situation concerning antibiotic use and resistance. Although they do not cover all aspects of use and resistance, they can be used to provide a general assessment of the overall situation. Secondary indicators are designed to provide information on more specific issues that are considered of importance for public health, but have a more restricted scope, or to encompass areas not fully covered by the primary indicator.

Table 3: European indicators on antibiotic use and resistance, data for Scotland in 2017.

<table>
<thead>
<tr>
<th>Antibiotic use in humans</th>
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</thead>
<tbody>
<tr>
<td>Primary indicator</td>
<td>Total use of antibiotic for systemic use (DDD per 1,000 inhabitants and per day)</td>
<td>25.5</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Ratio of the community use of broad-spectrum penicillins, cephalosporins, macrolides (except erythromycin) and fluoroquinolones to the use of narrow spectrum penicillins, cephalosporins and erythromycin (DDD per 1,000 inhabitants per day)</td>
<td>0.41:1</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Proportion of total hospital antibiotic use that are glycopeptides, 3rd- and 4th-generation cephalosporins, monobactams, carbapenems, fluoroquinolones, polymyxins, piperacillin and enzyme inhibitor, linezolid, tedizolid and daptomycin (DDD per 1,000 inhabitants per day)</td>
<td>11.5%</td>
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<table>
<thead>
<tr>
<th>Antibiotic resistance in humans</th>
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<tbody>
<tr>
<td>Primary indicator</td>
<td>Proportion of meticillin resistant S. aureus (MRSA)</td>
<td>76</td>
</tr>
<tr>
<td>Primary indicator</td>
<td>Proportion of E. coli resistant to 3rd generation cephalosporins</td>
<td>293</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Proportion of K. pneumoniae with combined resistance to aminoglycosides, fluoroquinolones and 3rd generation cephalosporins</td>
<td>25</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Proportion of S. pneumoniae resistant to penicillins</td>
<td>0</td>
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<tr>
<td>Secondary indicator</td>
<td>Proportion of <em>S. pneumoniae</em> resistant to macrolides</td>
<td>35</td>
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<tr>
<td>Secondary indicator</td>
<td>Proportion of carbapenem- resistant <em>K. pneumoniae</em></td>
<td>0</td>
</tr>
</tbody>
</table>

**Antibiotic use in food producing animals**

<table>
<thead>
<tr>
<th>Primary indicator</th>
<th>Overall sales of veterinary antimicrobials (mg/ population correction unit (PCU))</th>
</tr>
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<tbody>
<tr>
<td>Secondary indicator</td>
<td>Sales of 3rd- and 4th-generation cephalosporins (mg/PCU)</td>
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<tr>
<td>Secondary indicator</td>
<td>Sales of quinolones (mg/ PCU), specifying the proportion of fluoroquinolones</td>
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<tr>
<td>Secondary indicator</td>
<td>Sales of polymyxins (mg/ PCU)</td>
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</table>

**Antibiotic resistance in food producing animals**

<table>
<thead>
<tr>
<th>Primary indicator</th>
<th>Proportion of indicator <em>E. coli</em> from broilers, fattening turkeys, fattening pigs and calves, weighted by PCU, fully susceptible to a predefined panel of antimicrobials</th>
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</thead>
<tbody>
<tr>
<td>Secondary indicator</td>
<td>Proportion of samples positive for presumptive ESBL-/ AmpC-producing indicator <em>E. coli</em> from broilers, fattening turkeys, fattening pigs and calves weighted by PCU</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Proportion of indicator <em>E. coli</em> from broilers, fattening turkeys, fattening pigs and calves, weighted by PCU, resistant to at least three antimicrobials from different classes included in a predefined panel of antimicrobials</td>
</tr>
<tr>
<td>Secondary indicator</td>
<td>Proportion of indicator <em>E. coli</em> from broilers, fattening turkeys, fattening pigs and calves, weighted by PCU, resistant to ciprofloxacin</td>
</tr>
</tbody>
</table>

Data are collated and reported at UK level by Veterinary Medicines Directorate.

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Scottish One Health Antimicrobial Use and Antimicrobial Resistance Annual Report 2017
**Behavioural insights**

HPS, as part of controlling antimicrobial resistance in Scotland, has supported the Behavioural Insights into AMR team at Glasgow Caledonian University, led by Professor Paul Flowers. The team is an international and interdisciplinary group of social and health scientists with particular interest in behavioural and cultural change. The behavioural insights team is part of the Safeguarding Health through Infection Prevention (SHIP) group and has also been supported through the Scottish Healthcare Associated Infection Prevention Institute (SHAIPI).

Overall, the team’s work has focussed on using key approaches from behavioural and implementation science to detail novel, evidence-based and theoretically informed recommendations to reduce the drivers of AMR. The team has used a broad range of methods and theories to examine these drivers.

With an emphasis on ‘One Health’, the team has worked with a range of populations and across diverse settings. Populations have included hospital based health professionals, the public, pet-owners, parents, companion animal veterinarians, dairy farmers, those involved with the food industry and experts on AMR.

Highlights of the team’s work include systematic reviews which have made a major contribution to understanding the effectiveness of previous attempts to increase the public’s awareness and engagement with the topic of AMR. These reviews resulted in a series of detailed recommendations of how to improve the public’s engagement through more narratively oriented, emotionally meaningful interventions which are clearly distinct and different to those which have been commissioned in the past. Equally, the team has completed ground-breaking work in relation to understanding the systemic aspects of AMR. Through their work with highly diverse experts across the realm of AMR, they have detailed how important it is to focus on the systemic drivers of AMR. These include improving inter-sectorial communication, reducing the unhelpful reciprocal distribution of culpability and the diffusion of responsibility, and ensuring there are resources and structures in place to focus upon the system of AMR in addition to focusing on specific populations and behaviours within it.
### List of abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMR</td>
<td>Antimicrobial Resistance</td>
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<tr>
<td>AMRHAI</td>
<td>Antimicrobial Resistance and Healthcare Associated Infections</td>
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<td>AMTs</td>
<td>Antimicrobial Management Teams</td>
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<td>AMU</td>
<td>Antimicrobial Use</td>
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<td>ASP</td>
<td>Antimicrobial Stewardship Programme</td>
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<td>AST</td>
<td>Antimicrobial Susceptibility Testing</td>
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<td>BASHH</td>
<td>British Association for Sexual Health and HIV</td>
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<td>BSAC</td>
<td>British Society for Antimicrobial Chemotherapy</td>
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<tr>
<td>CLSI</td>
<td>Clinical and Laboratory Standards Institute</td>
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<td>CMO</td>
<td>Chief Medical Officer</td>
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<td>CNO</td>
<td>Chief Nursing Officer</td>
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<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
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<td>CPE</td>
<td>Carbapenemase-producing Enterobacteriaceae</td>
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<td>CPO</td>
<td>Carbapenemase-producing Organism</td>
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<td>CRA</td>
<td>Clinical Risk Assessment</td>
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<td>DDD</td>
<td>Defined Daily Doses</td>
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<td>ECDC</td>
<td>European Centre for Disease Prevention and Control</td>
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<td>EEA</td>
<td>European Economic Area</td>
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<td>EFSA</td>
<td>European Food Safety Authority</td>
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<td>EMA</td>
<td>European Medicines Agency</td>
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<td>ESBLs</td>
<td>Extended-spectrum beta-lactamases</td>
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<td>EU</td>
<td>European Union</td>
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<td>EUCAST</td>
<td>European Committee on Antimicrobial Susceptibility Testing</td>
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<td>EWS</td>
<td>Early Warning System</td>
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<td>FSS</td>
<td>Food Standards Scotland</td>
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<td>GASS</td>
<td>Gonococcal Antibiotic Surveillance in Scotland</td>
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<td>GPs</td>
<td>General Practitioners</td>
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<tr>
<td>HCAI</td>
<td>Healthcare Associated Infection</td>
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<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<tr>
<td>HL-AziR</td>
<td>High Level Azithromycin Resistant</td>
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<td>HPS</td>
<td>Health Protection Scotland</td>
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<td>ISD</td>
<td>Information Services Division</td>
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<td>ITU</td>
<td>Intensive Therapy Unit</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>IV</td>
<td>Intravenous</td>
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<td>KPI</td>
<td>Key Performance Indicator</td>
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<tr>
<td>MDRO</td>
<td>Multi-Drug Resistant Organism</td>
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<tr>
<td>MRSA</td>
<td>Meticillin Resistant <em>Staphylococcus aureus</em></td>
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<tr>
<td>NATSAL-3</td>
<td>National Survey of Sexual Attitudes and Lifestyles</td>
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<td>NDM</td>
<td>New-Delhi-metallo-beta-lactamases</td>
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<td>NICE</td>
<td>National Institute for Health and Care Excellence</td>
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<td>NIPCM</td>
<td>National Infection Prevention Control Manual</td>
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<td>OBDs</td>
<td>Occupied Bed Days</td>
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<td>OXA</td>
<td>Oxacillinase</td>
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<td>Polymerase Chain Reaction</td>
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<td>Population Correction Unit</td>
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<td>Public Health England</td>
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<td>PHM</td>
<td>Public Health Microbiology</td>
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<td>PID</td>
<td>Pelvic Inflammatory Disease</td>
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<tr>
<td>PT</td>
<td>Phage type</td>
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<tr>
<td>SAC</td>
<td>Scottish Agricultural College</td>
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</table>
References


