ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Scottish One Health Antimicrobial Use and Antimicrobial Resistance in 2023

Annual Report

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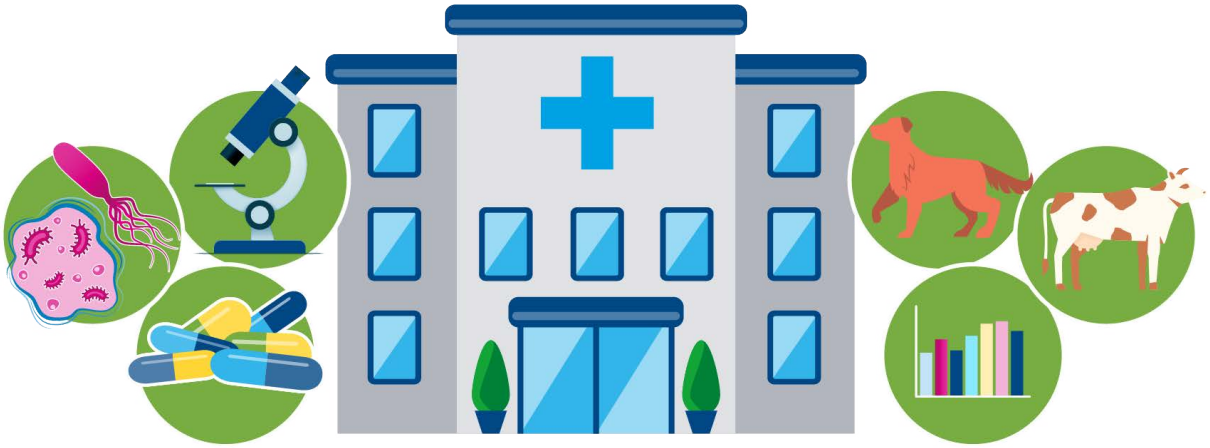
Contents



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About ARHAI Scotland

ARHAI Scotland's overall vision is to

Enable Scotland to adopt an evidence based and innovative approach to minimising the burden of infection and antimicrobial resistance (AMR).

Our mission is to

Enhance the health and wellbeing of the population by reducing infection and antimicrobial resistance within Scottish care settings.

We will achieve this by:

- establishing a robust evidence base for best practices
- developing mechanisms for monitoring key priority areas
- connecting with the broader health, social care, and public health systems
- collaborating with key delivery partners, including NHSScotland boards, care providers, and other national bodies as commissioned by the Scottish Government.

The work of ARHAI Scotland is underpinned by delivering a wide range of functions, working with stakeholders across health and care, and beyond to fulfil these functions. The Scottish One Health Antimicrobial Use and Antimicrobial Resistance (SONAAR) programme is one of six priority programmes that contributes to ARHAI Scotland's mission to enhance the health and wellbeing of the population by reducing infection and antimicrobial resistance within Scottish care settings.

The SONAAR programme aims to:

- Take an internationally recognised 'One Health' approach to tackling AMR which acknowledges that the health of humans, animals and the environment are interconnected.
- Provide intelligence and evidence for action, informing the development of local and national interventions and initiatives to tackle AMR.
- Sustain actions to preserve antimicrobials, reduce drug resistant infections and reduce our service users' risk from infections caused by micro-organisms that are resistant to antimicrobials.

What is antimicrobial resistance and what is being done to control it?

Antimicrobial resistance (AMR) occurs when microbes, such as bacteria and fungi, change and no longer respond to medicines designed to kill them. This change is an adaption of the microbe's genetics and is driven by the exposure of the microbe to antimicrobials in humans, animals and the environment. The result of this AMR is that treatments like antibiotics can become ineffective, and infections become increasingly difficult or impossible to treat.

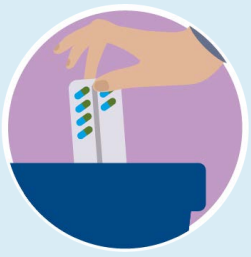
Antimicrobials, including antibiotics, save lives through their ability to prevent and treat infection. These infections can be minor but can also be serious and life-threatening. It has been estimated that **antimicrobials add 20 years on average to life expectancy** across the world. This ability to prevent and treat infections using antimicrobials is central to delivery of healthcare and managing infectious disease, making surgery and childbirth safer, protecting people with cancer and supporting animal welfare and food production. Organisms which are resistant to antimicrobials can spread through people, animals, food and the environment. This means AMR is a major public health threat.

Antimicrobial use (AMU) and spread of infection in humans, animals and the environment contribute to the development of resistant infections. Development of AMR is a complex evolutionary process. Some of the main drivers of AMR are shown below:

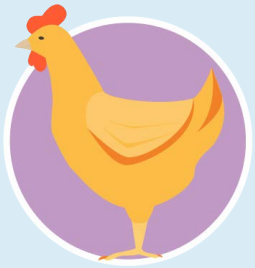
Animicrobial Resistance - Contributing Factors

Antibiotic resistance happens when bacteria change and become resistant to the antibiotics used to treat the infections they cause.

Over-prescribing of antibiotics



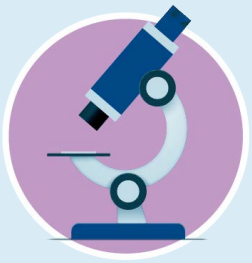
Patients not finishing their treatment



Over-use of antimicrobials in agriculture

Poor infection prevention and control in healthcare settings

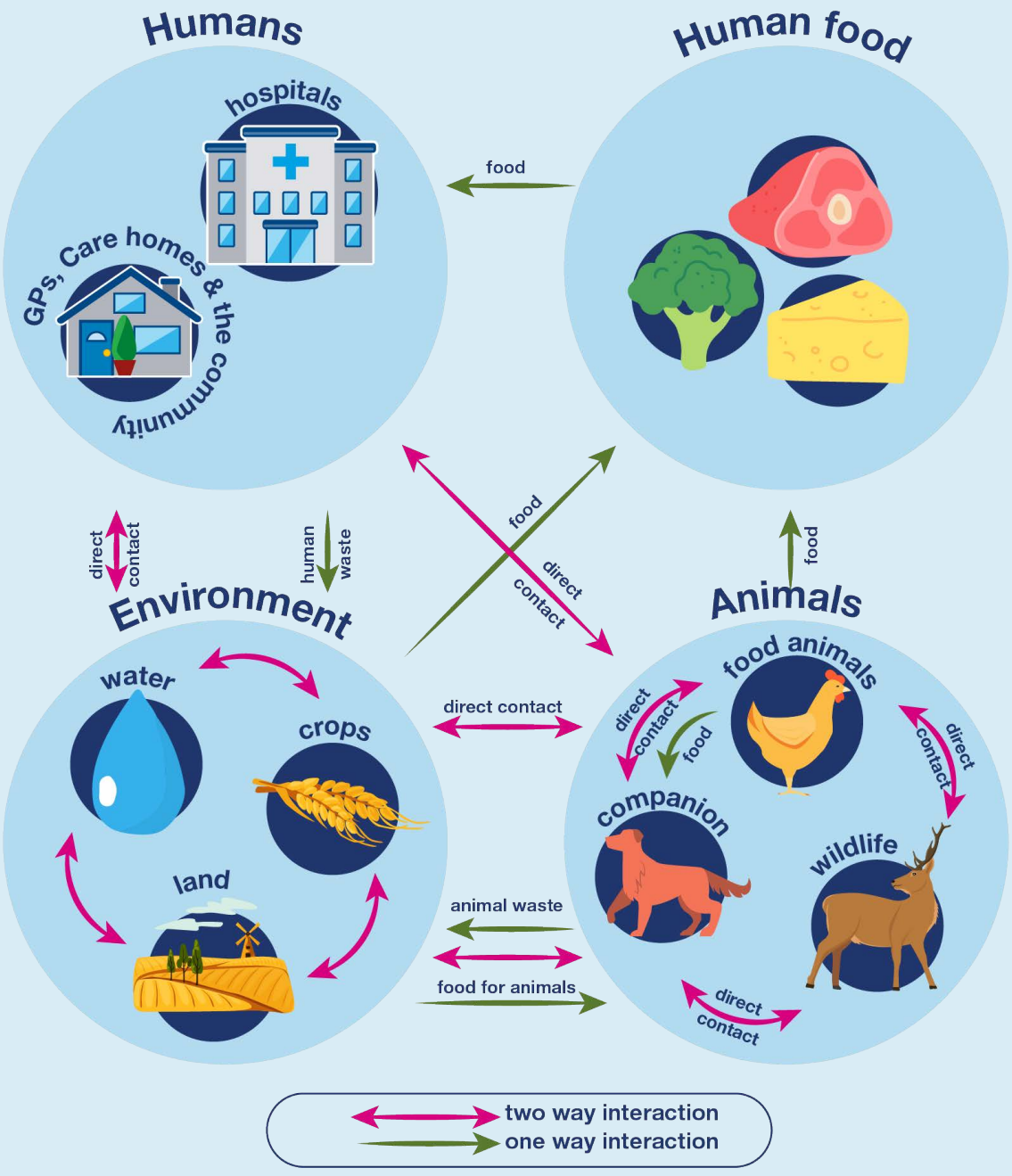
Lack of hygiene and poor sanitation



Lack of new antibiotics being developed

A co-ordinated cross sectoral response is needed to address the threat from AMR. This is called a ‘One Health’ approach, which recognises that many of the same bacteria infect humans and animals and may be found in the environment as they share the same ecosystem. The links and transmission between different species and parts of the ecosystem are complex (see graphic below) and so efforts in all sectors are required to reduce the threat from AMR.

One Health approach to antimicrobial resistance

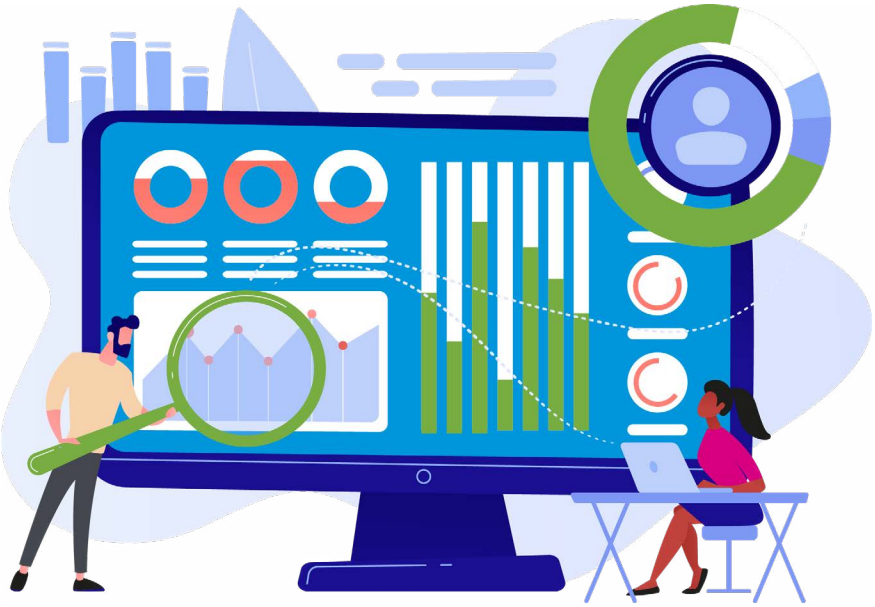


AMR is a global concern. Actions to tackle AMR in Scotland, within the United Kingdom and internationally are underway with ARHAI Scotland playing its part. In January 2019, the UK Government published a vision for AMR in 20 years **'Contained and controlled: The UK's 20-year vision for antimicrobial resistance'.**

This SONAAR report is published at an important point with the transition from the 2019-2024 AMR national action plan, **'Tackling Antimicrobial Resistance 2019–2024'** to the 2024–2029 national action plan (NAP), **'Confronting Antimicrobial Resistance'.** ARHAI Scotland contributed to the development of the 2024–2029 NAP and will be crucial to the implementation in Scotland.

ARHAI Scotland will have a continued role in providing intelligence and evidence to support optimisation of antibiotic use, and containment and control of AMR. This will be delivered through ongoing development of epidemiological evidence on trends in AMU and AMR to inform local and national interventions and initiatives in human and animal health.

The timeframe covered by this report includes the COVID-19 pandemic, which impacted healthcare delivery in both hospital and community settings, making comparisons across the years difficult. Results presented in this report must be interpreted with due caution.



Antimicrobial use in humans

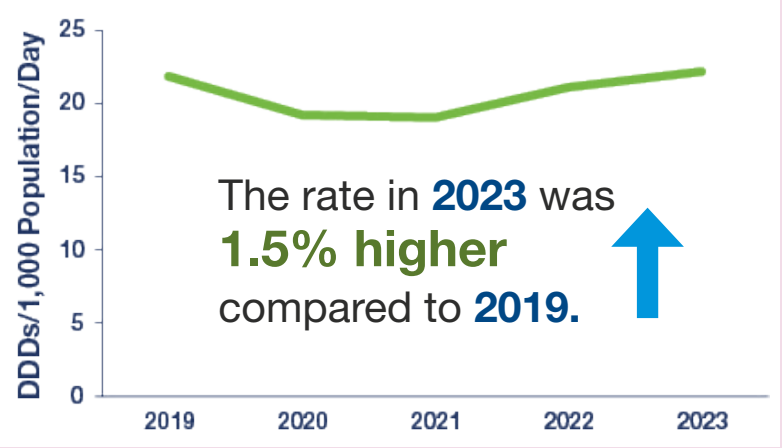
Total antibiotic use in humans

All use of antibiotics will drive development of AMR. To minimise resistance, use of antibiotics must be optimised through reducing their inappropriate use, for example, when antibiotics are taken when they are not needed, or when taken for longer than necessary, or where a broad-spectrum antibiotic is used unnecessarily.

Total use of antibiotics in humans

In **2023**, **22.2 defined daily doses (DDDs)** per 1,000 population per day (DDDs/1,000/day) were used.

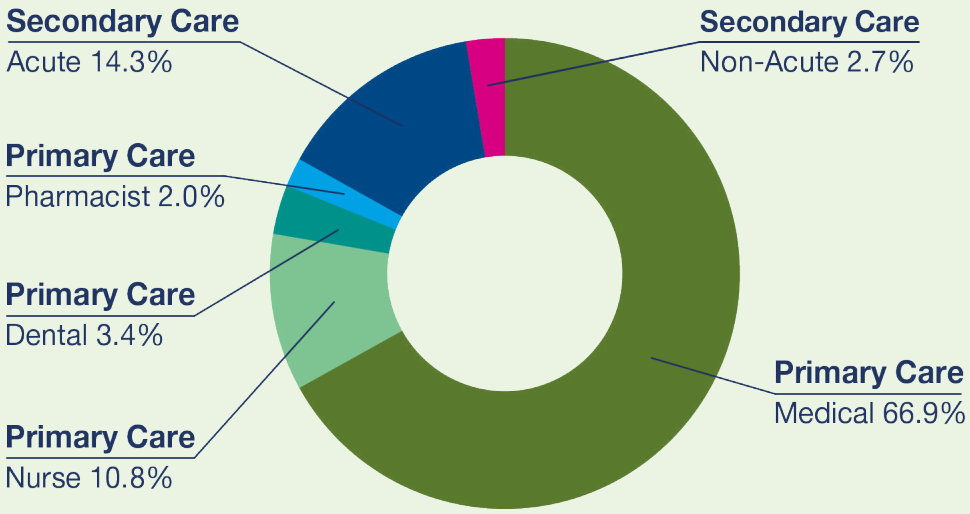
There has been a **5.1% increase** in the rate between **2022** and **2023.**



Antibiotic use in Scotland by prescriber type

In **2023**, **83.1%** of antibiotic use (DDDs) was in primary care. Antibiotic use in acute hospitals accounted for **14.3%** of antibiotic use (DDDs) with non-acute hospitals accounting for **2.7%**.

It is vital for clinicians in all settings to use every opportunity to optimise antibiotic use.



Percentage of all antibiotics in Scotland that belonged to the Access group

To avoid unnecessary use of broad-spectrum antibiotics an adapted version of the World Health Organization (WHO) **Access, Watch, Reserve (AWaRe)** classification of antibiotics is used to monitor antibiotic use in Scotland.

Access antibiotics should be used as **first line treatment** for most common infections.

In **2023**, Access antibiotics accounted for **64.5%** of total antibiotic use (DDDs), compared to **64.3%** in **2022** and **61.0%** in **2019**.

This may reflect increasing compliance with prescribing policies. Further increases are required to achieve the target that by **2029** at least **70%** of antibiotics should be Access antibiotics.

ARHAI Scotland will continue to make available to NHS boards clinically meaningful intelligence on antibiotic use in humans through **Discovery dashboards** and presentations to stakeholders such as the Scottish Antimicrobial Prescribing Group.

This enables NHS boards to track local progress against AMR National Action Plan targets, Scottish Government standards on antibiotic use, and to identify areas for focussed local improvement activity and minimisation of health inequalities.

There will be a focus on scoping and highlighting variation in antibiotic use, where possible, by factors such as deprivation, age, gender, geography, region, setting and ethnicity.

For detailed information on use of different antibiotics see **Supplementary Data.**

Antibiotic use in primary care

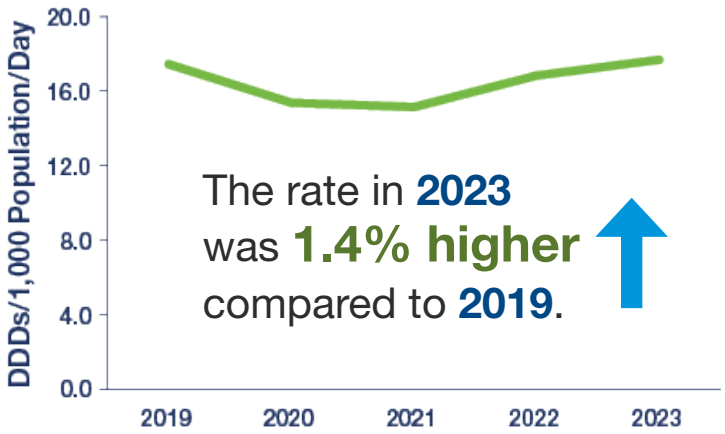
Wherever antibiotics are used in the community the aim must be to optimise their use to make sure the right antibiotic is prescribed, only to those where antibiotics are needed, at the right time and for the minimum recommended duration. Prescribing and use of antibiotics in the community is increasingly undertaken by health professionals other than doctors as a response to changing models of delivery of health care in Scotland. Providing intelligence on the trends in antibiotic use will support planning, delivery and assessment of impact of these changes.

Antibiotic use in primary care (excluding dental)

A key approach to optimising antibiotic use in primary care is to minimise use for symptoms such as coughs, colds, sore throats, and earache in otherwise fit and healthy people.

In **2023** **17.7 DDDs per 1,000 population per day** were used.

There has been an **5.1% increase** in the rate between **2022** and **2023**.



When expressed using items, antibiotic use in **2023** was **1.95** items per 1,000 population per day. This was **4.8% higher** than in **2022**.

The rate in **2023** was **7.2%** higher compared to **2019**.

In **2023**, **31.2%** of the Scottish population received **at least one course of antibiotics** in primary care, excluding dental, compared to **29.7%** in **2022**.

The increase in antibiotic use in **2023** compared to **2022** may be due to a continued impact of the temporary change in prescribing guidelines following the increase in Group A streptococcal infections in late **2022** and spring **2023**.

Use of Access antibiotics in primary care

In **2023**, **62.8%** of antibiotic DDDs in primary care were from the Access category, compared to **62.6%** in **2022**.

When expressed using items, **79.9%** of antibiotics used in **2023** were from the Access category, compared to **79.6%** in **2022**.

Primary care accounts for the majority of antibiotic use. Increasing adherence with evidenced based prescribing guidelines is needed to drive the ambitions for an increased use of Access antibiotics as a proportion of total antibiotic use in humans.

Duration of treatment

Clinical guidelines recommend that where antibiotics are required for respiratory infection, treatment should be for five days. Ensuring antibiotics are not taken for any longer than is clinically needed is a key way to reduce unnecessary exposure to antibiotics and to minimise AMR. Maximising the use of five-day courses is an important way to optimise antibiotic use.

In **2023**, **67.4%** of courses of amoxicillin 500mg capsule prescriptions were for five days duration, compared to **64.7%** in **2022**.

In **2023**, **34.7%** of courses of doxycycline 100mg capsule and tablet prescriptions were for five days duration, compared to **32.1%** in **2022**.

This may suggest improving compliance with antibiotic prescribing policies, however there is room for further optimisation and minimisation of variation. Use of pre-set five day durations with primary care based prescribing systems could increase use of five day courses and reduce overall antibiotic use.

Of the total number of antibiotic items prescribed in primary care in 2023

71.6% of **all antibiotic items** were written by **GPs**

16.0% of items were written by **nurse prescribers**

8.0% were written by **dentists**

4.4% were written by **pharmacists**

The evolving multi-professional approach to antibiotic prescribing in primary care in Scotland reflects changes in how individuals present for care and treatment in the community. The changing nature of the clinicians prescribing antibiotics means that communications and education to optimise antibiotic use through local and national antimicrobial stewardship (AMS) initiatives must include all relevant professionals.

For detailed information on antibiotic use in primary care see **Supplementary Data**.

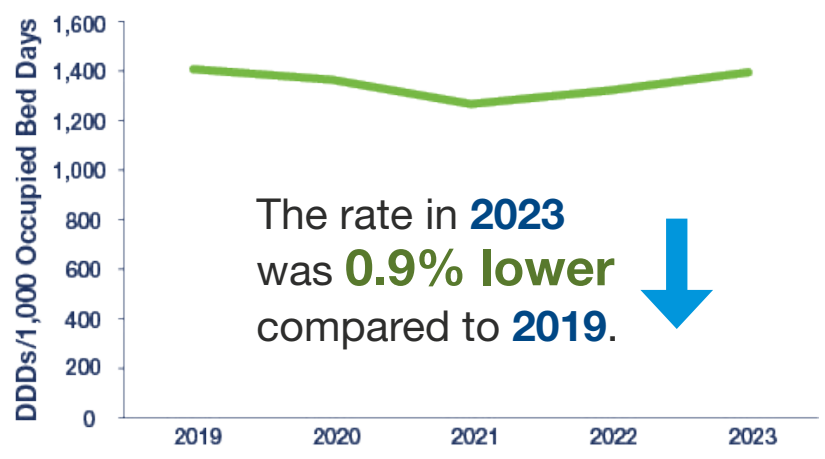
Antibiotic use in acute hospitals

Optimising antibiotic use in acute hospitals will initially involve initiatives to ensure the correct diagnosis to support a decision about whether antibiotics are required. Decisions for clinicians on which antibiotics to use on an empiric basis are supported by evidence based antibiotic guidelines. These guidelines are intended to support clinicians through promoting use of narrow-spectrum antibiotics where appropriate and minimising inappropriate use of broader spectrum treatments. Equally important are initiatives to ensure the correct route, optimal duration and timely de-escalation where clinically appropriate.

Antibiotic use in acute hospitals

In **2023**, antibiotic use was **1,394.5 DDDs** per 1,000 occupied bed days.

There has been a **5.5% increase** in the rate between **2022** and **2023**.



Choice of antibiotic

Access antibiotics accounted for **64.0%** of total antibiotic DDDs in **2023**, compared to **63.7%** in **2022**.

In **2019**, a national indicator was developed by Scottish Government with support from ARHAI Scotland and Scottish Antimicrobial Prescribing Group (SAPG), to encourage compliance with local antibiotic prescribing policies and minimise inappropriate use of broad-spectrum antibiotics.

National indicator: **at least 60% of total antibiotic use in acute hospitals to be Access antibiotics by 2024.**

Route of administration

Selecting the most appropriate route of administration is vital to ensure infection is treated effectively while not putting patients at risk from unnecessary use of the intravenous (IV) route of administration. Regular clinician review of hospital patients receiving antibiotics by IV injection to prompt switching to oral therapy or discontinuing antibiotics remains an important element of AMS in Scotland.

In **2023**, antibiotics given intravenously accounted for **29.4%** of total antibiotic use (DDDs) in acute hospitals compared to **29.9%** in **2022**.

A national indicator was developed to measure progress with achieving reliable and timely review of **IV antibiotic therapy: IV antibiotic use in secondary care to be no higher in 2023 than in 2018**.

In **2023**, the **rate of IV antibiotic use** in all secondary care was **0.95** DDDs per 1,000 population per day compared to **0.91** in **2022** and **0.96** in **2018**.

For detailed information on antibiotic use in acute hospitals see **Supplementary Data**.

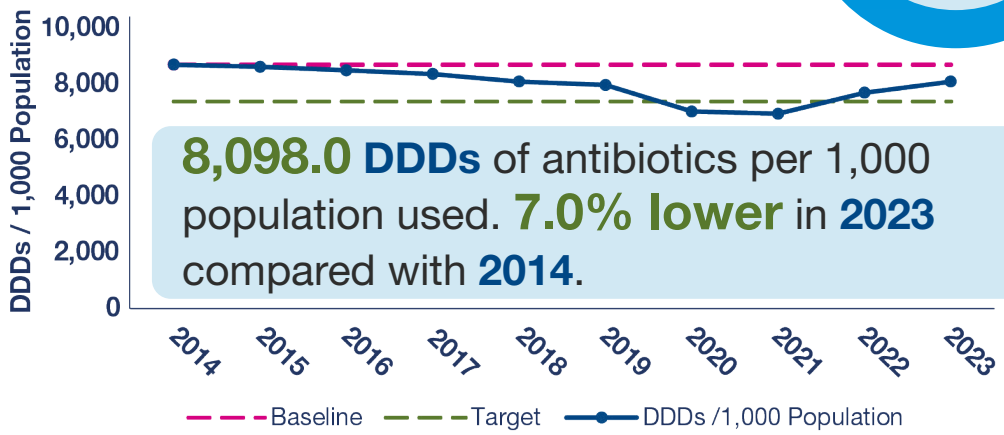
UK National Action Plan Targets

The UK AMR national action plan '**Tackling antimicrobial resistance 2019–2024**' set out measures of success to ensure progress, including targets on AMU.

In 2023...

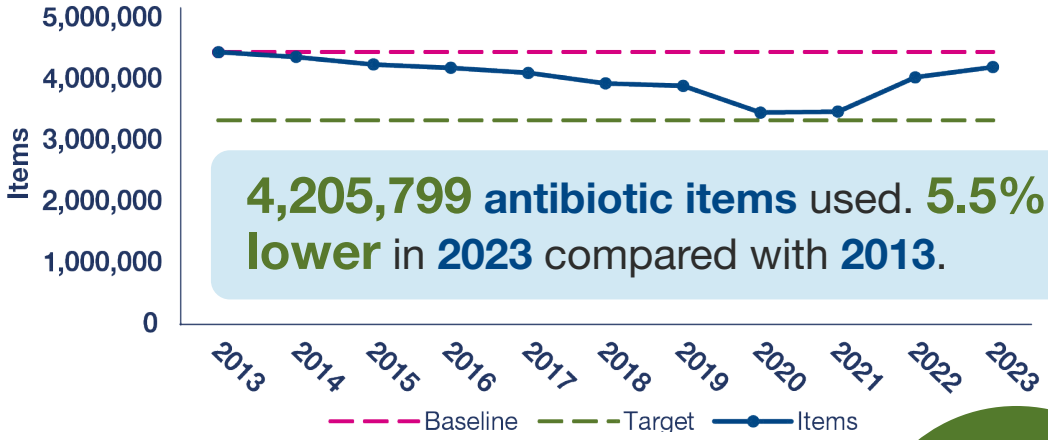
Ambition to reduce antimicrobial use in humans by 15% by 2024 (2014 baseline)

Target not achieved



8,098.0 DDDs of antibiotics per 1,000 population used. **7.0% lower** in **2023** compared with **2014**.

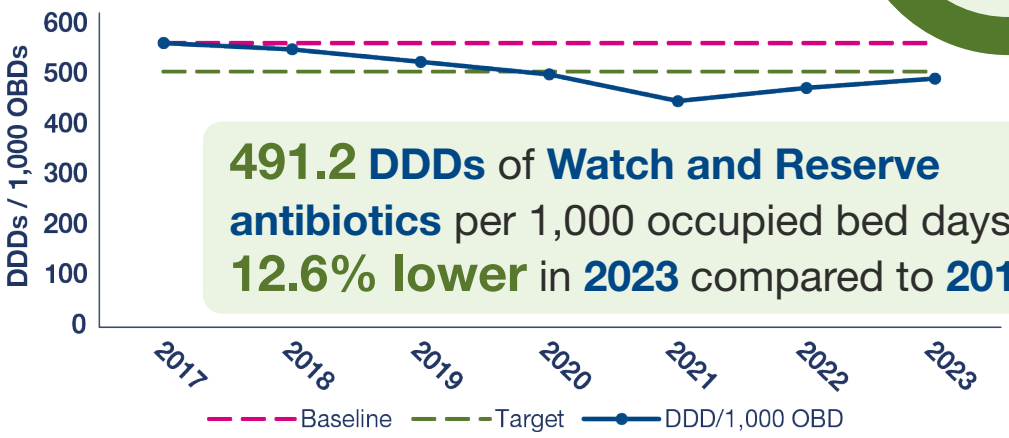
Ambition to reduce primary care antimicrobial use by 25% by 2024 (2013 baseline)



4,205,799 antibiotic items used. **5.5% lower** in **2023** compared with **2013**.

Target achieved

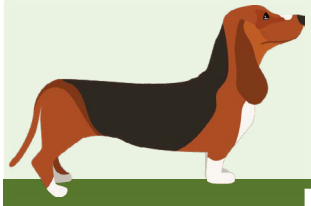
Ambition to reduce use of Watch and Reserve antibiotics by 10% by 2024 (2017 baseline)



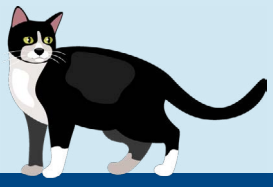
491.2 DDDs of **Watch and Reserve antibiotics** per 1,000 occupied bed days used. **12.6% lower** in **2023** compared to **2017**.

Antimicrobial use in companion animals

Data on AMU in dogs and cats were obtained from a small number of veterinary practices in Scotland contributing voluntarily to the **Small Animal Veterinary Surveillance Network (SAVSNET)** and therefore cannot be assumed to be representative of all companion animal practices in Scotland.



In 2023, **13** veterinary practices in Scotland contributed data from **54,277** individual consultations and **30,961** individual animals.

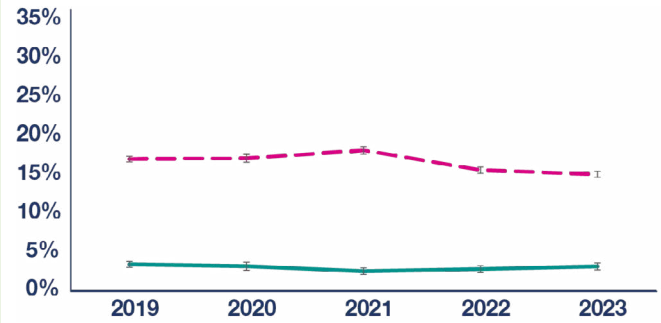


Dogs

15.0% of the **37,564** total consultations resulted in prescription of **antimicrobials**.

This was **3.4% lower** compared to **2022** and **11.5% lower** compared to **2019**.

The percentage of prescriptions that were HP-CIAs* in **2023** **remained stable** compared to **2022** and **2019**.

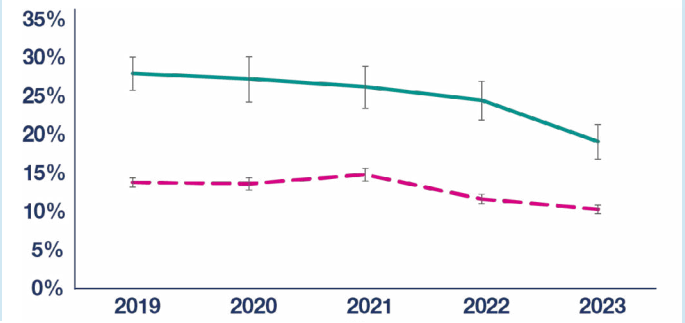


Cats

10.5% of the **13,755** total consultations resulted in prescription of **antimicrobials**.

This was **11.3% lower** compared to **2022** and **25.0% lower** compared to **2019**.

The percentage of prescriptions that were HP-CIAs* in **2023** was **21.8% lower** compared to **2022** and **31.5% lower** compared to **2019**.



Consultations resulting in prescription of at least one antimicrobial (%)

Total antimicrobials prescribed that were HP-CIA (%)

*High priority critically important antimicrobials (HP-CIAs) are: carbapenems, cefovecin, cephalosporins (3rd and later generations), ciprofloxacin, enrofloxacin, marbofloxacin, ofloxacin, orbifloxacin and pradofloxacin

For more information on AMU in companion animals see **Supplementary Data**.

Antimicrobial resistance in humans

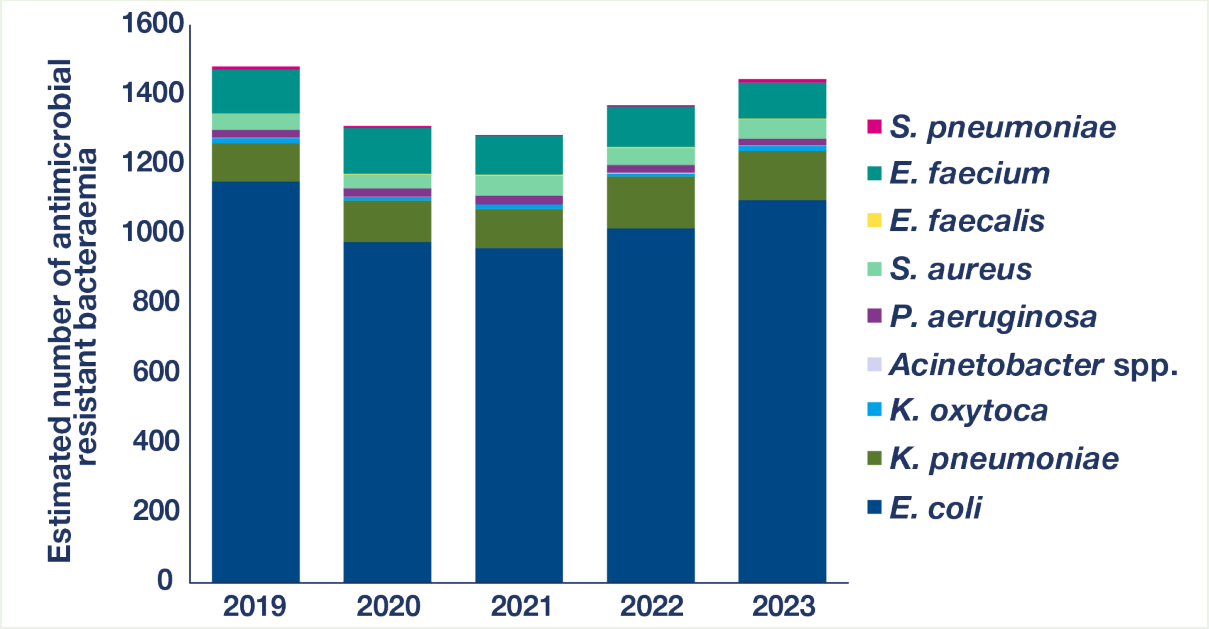
Antimicrobial resistant infections are harder to treat and result in prolonged hospital stays, use of more complex antimicrobial therapy and can lead to worse outcomes for patients. Reducing the burden of antimicrobial resistant infections is critical to controlling AMR by reducing the further spread of antimicrobial resistant micro-organisms and the need for antimicrobials. Robust intelligence and metrics are required to plan, prioritise, and evaluate interventions to reduce the burden.

Antimicrobial Resistance Burden

In **2023**, **16.7%** of bacteraemia in select priority organisms were resistant to **at least one** key antibiotic, an estimated **1,445** resistant bacteraemia.

Of those, **88.2%** were caused by drug resistant **Gram-negative bacteria**.

The most common organism causing drug resistant bacteraemia was ***Escherichia coli* (*E. coli*)**, followed by ***Klebsiella pneumoniae* (*K. pneumoniae*)** and ***Enterococcus faecium* (*E. faecium*)**.



25.5% of ***E. coli* bacteraemia** in Scotland were resistant to at least one key antibiotic.

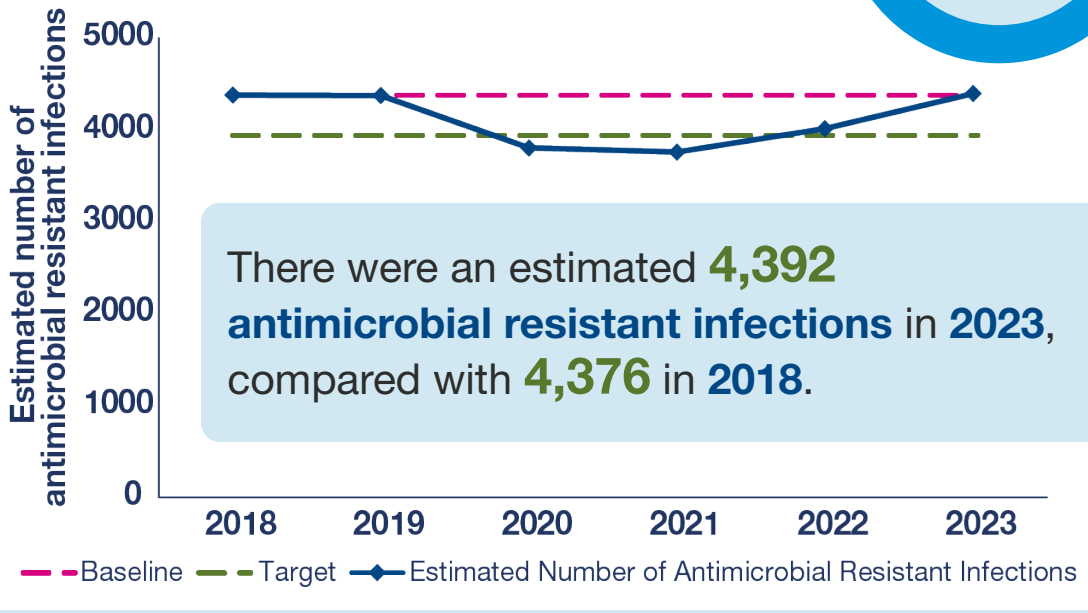
For more detailed information see **Appendix 2** and **Supplementary Data**.

UK National Action Plan Targets

The UK antimicrobial resistance national action plan '**Tackling antimicrobial resistance 2019-2024**' set a target to reduce antimicrobial resistant infections. This target is measured using an estimate of the total number of antimicrobial resistant infections caused by a specified set of organisms. The number of resistant surgical site infections, urinary tract infections, respiratory infections and other severe infections are estimated from the number of resistant bacteraemia (see **Appendix 2** for further details).

Target not achieved

Ambition to reduce the incidence of a specified set of drug-resistant infections by 10% by 2024 (2018 baseline)



There were an estimated **4,392 antimicrobial resistant infections** in **2023**, compared with **4,376** in **2018**.

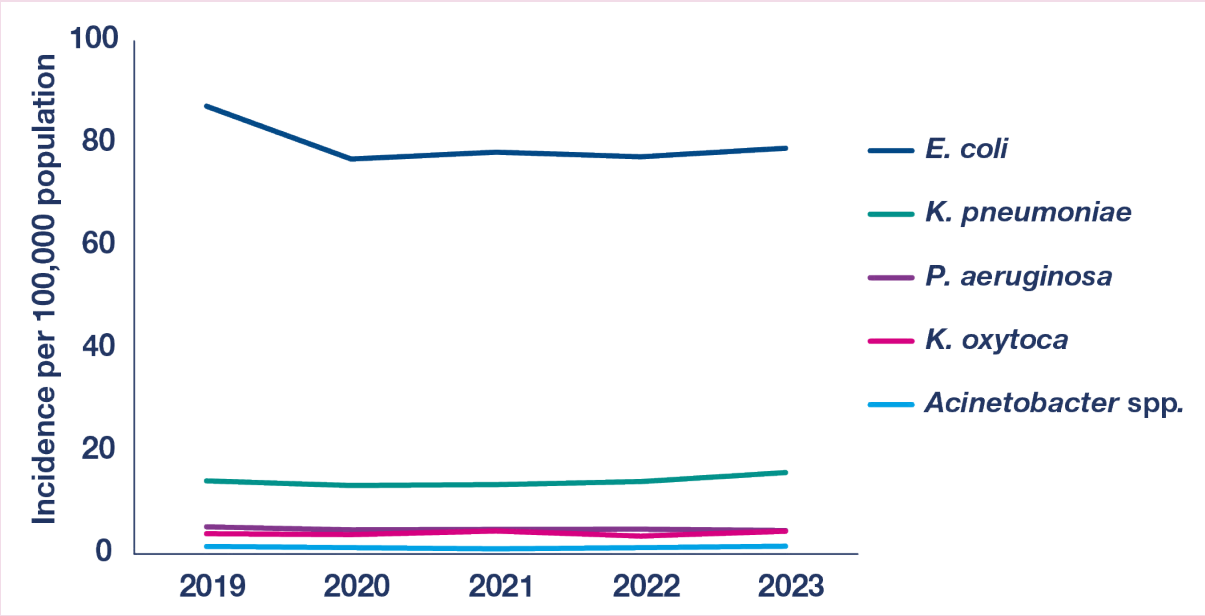
In 2024, ARHAI Scotland will continue to monitor the burden of antimicrobial resistant bacteraemia infections, in line with the new UK antimicrobial resistance national action plan: '**Confronting antimicrobial resistance 2024-2029**'.

For more information on the burden of antimicrobial resistant bacteraemia and infections see **Supplementary Data**.

AMR in Gram-negative organisms

Gram-negative bacteria are a common cause of serious infection in both healthcare and community settings. AMR in Gram-negative bacteria, particularly *E. coli*, significantly contributes to the overall burden of AMR.

In **2023**, there were **5,744** Gram-negative bacteraemia in Scotland, caused by five key Gram-negative pathogens.



Between **2022** and **2023**:

The **incidence** of ***Klebsiella oxytoca* (*K. oxytoca*)** and ***K. pneumoniae* bacteraemia increased** by **27.4%** and **12.5%** respectively.

The **incidence** of ***E. coli***, ***Pseudomonas aeruginosa* (*P. aeruginosa*)**, and ***Acinetobacter* species bacteraemia remained stable**.

See ARHAI **Scotland 2023 Annual Report** for further information on *E. coli* bacteraemia in Scotland.

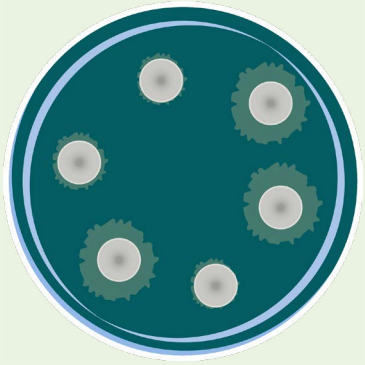
Between **2022** and **2023**:

Resistance to key antibiotics in **Gram-negative bacteraemia** has **remained stable**, ↔

with the exception of ***E. coli***, where resistance to **temocillin decreased**. ↓

Comparing **2023** to **2019**:

- The **resistance** of ***E. coli*** **bacteraemia** to **co-amoxiclav** and **trimethoprim** was **lower** in **2023** compared to **2019**. ↓
- The **resistance** of ***K. pneumoniae*** to **cefotaxime/ ceftriaxone** and **ceftazidime** was **higher** in **2023** compared to **2019**. ↑



Gram-negative bacteraemia data:

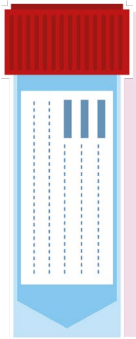
- Are shared via **Discovery Dashboards** enabling board comparisons.
- Inform quality improvement initiatives.
- Guide empirical antibiotic use to improve patient outcomes.

For information on AMR in Gram-negative organisms see **Supplementary Data**.

For further information on Discovery Dashboards see **Public Health Scotland**.

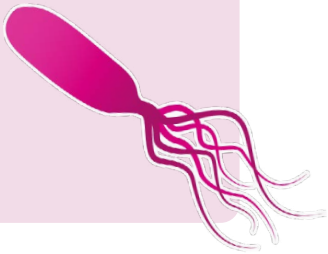
Urinary tract infections caused by *E. coli*

Urinary tract infections (UTIs) are commonly diagnosed in community and healthcare settings and AMR in urinary isolates significantly adds to the burden of AMR. Monitoring AMR in urinary isolates provides intelligence that underpins decision making and local prescribing policies.



E. coli was the most commonly reported organism in urinary isolates.

In **2023**, there were **167,603** episodes of ***E. coli*** isolated from urine.



Between **2022** and **2023**, **resistance** of ***E. coli*** to key antibiotics including **amoxicillin/ampicillin**, **cefotaxime/ceftriaxone**, **ceftazidime**, **ciprofloxacin**, **gentamicin**, **piperacillin-tazobactam** and **trimethoprim** **increased**.

Resistance to **co-amoxiclav**, **meropenem** and **nitrofurantoin** **remained stable**.

ARHAI Scotland use these data to support SAPG and NHS boards' Antimicrobial Management Teams (AMTs) to optimise antibiotic prescribing and stewardship ensuring empiric guidelines are based on current trends in AMR.

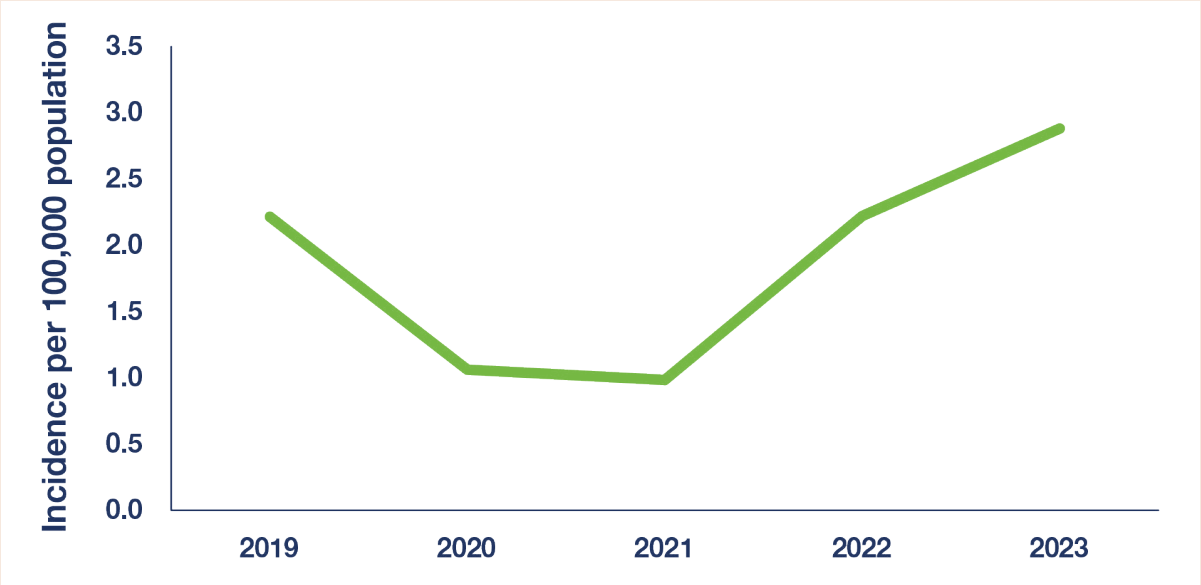
For further information on AMR in E. coli urinary isolates see **Supplementary Data**.

Carbapenemase-producing organisms

Carbapenems are beta-lactam antibiotics with a very broad spectrum of activity, often reserved as last-line agents for the treatment of bacterial infections. The primary mechanism of carbapenem resistance is the production of acquired carbapenemases, enzymes which inactivate carbapenem antibiotics rendering many beta-lactams ineffective. Bacteria that have the ability to do this are referred to as carbapenemase-producing organisms (CPOs).

In **2023**, there were **157** cases of **CPO** reported in Scotland, compared to **121** in **2022**.

The annual **CPO** incidence was **2.9** per 100,000 population.



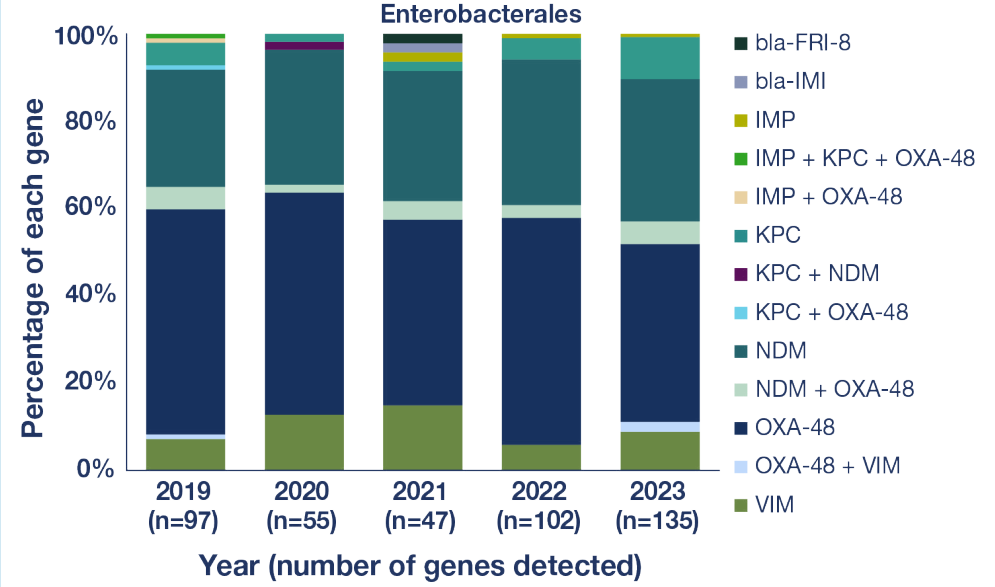
The incidence of CPO reduced during the COVID-19 pandemic in line with fewer hospital admissions and restrictions on international travel.

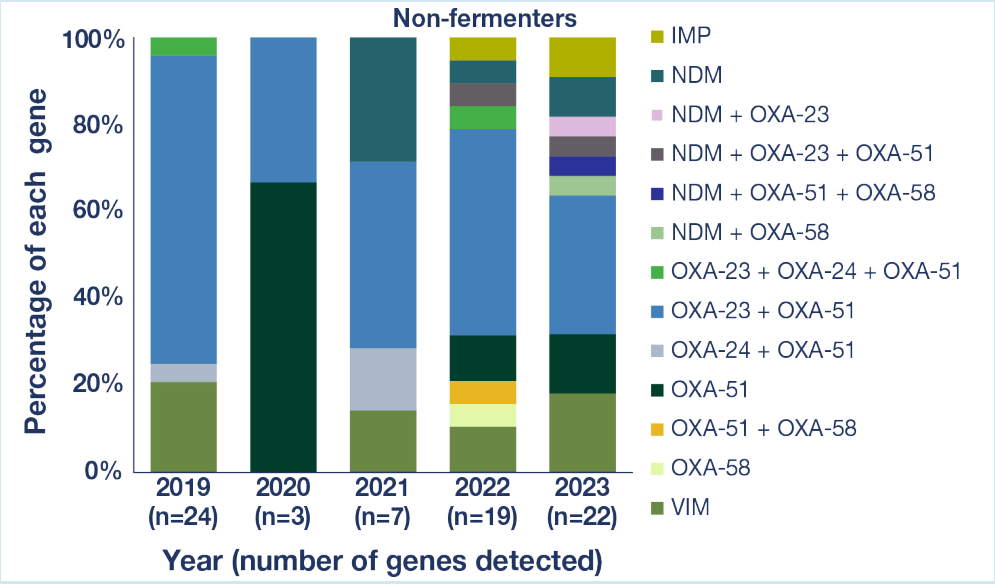
In **2023** the incidence was **29.8% higher** than in **2022** and **30.1% higher** than in **2019**.

86.0% of CPOs identified in **2023** were **carbapenemase-producing Enterobacterales (CPE)**.

The remaining were **non-fermenters** (***Acinetobacter* species** and ***Pseudomonas* species**).

In **2023**, the most frequently detected carbapenemase genes in **Enterobacterales** were **oxacillinase (OXA)-48-like** and **New Delhi Metallo-beta-lactamase (NDM)**. The most frequently detected carbapenemase genes in **non-fermenters** were combinations containing **OXA-51** and **OXA-23**.





In 2024, ARHAI Scotland will continue to develop further intelligence relating to CPO epidemiology in Scotland. The findings will be used to support SAPG and the Scottish Microbiology and Virology Network, driving forward the antibiotic stewardship agenda.

For further information on CPOs see **Supplementary Data**.

Antimicrobial resistance in Gram-positive organisms

Enterococcal bacteraemia

Enterococci are distributed widely in nature and are found in humans, animals, soil, food and plants. They are a commensal of the gastrointestinal tract of most species, including humans. *Enterococcus* species survive in harsh environments and can cause infections in humans such as UTI, infective endocarditis and bacteraemia.

In **2023**, the annual **incidence** of ***E. faecalis*** and ***E. faecium*** **bacteraemia** was **8.5** and **6.1** per 100,000 population, respectively.

The **five year trend** in **incidence** of ***E. faecalis*** and ***E. faecium*** **bacteraemia** has **remained stable**. ↔

AMR in *E. faecalis*

In **2023**, vancomycin resistance was reported in **0.5%** of ***E. faecalis*** blood isolates.

Over the last five years, teicoplanin and **vancomycin resistance** has **remained low**.

In ***E. faecalis*** blood isolates between **2022** and **2023**:

- **resistance** to **high level gentamicin** has **remained stable**.
- **resistance to teicoplanin, vancomycin** and **linezolid** has **remained low**.

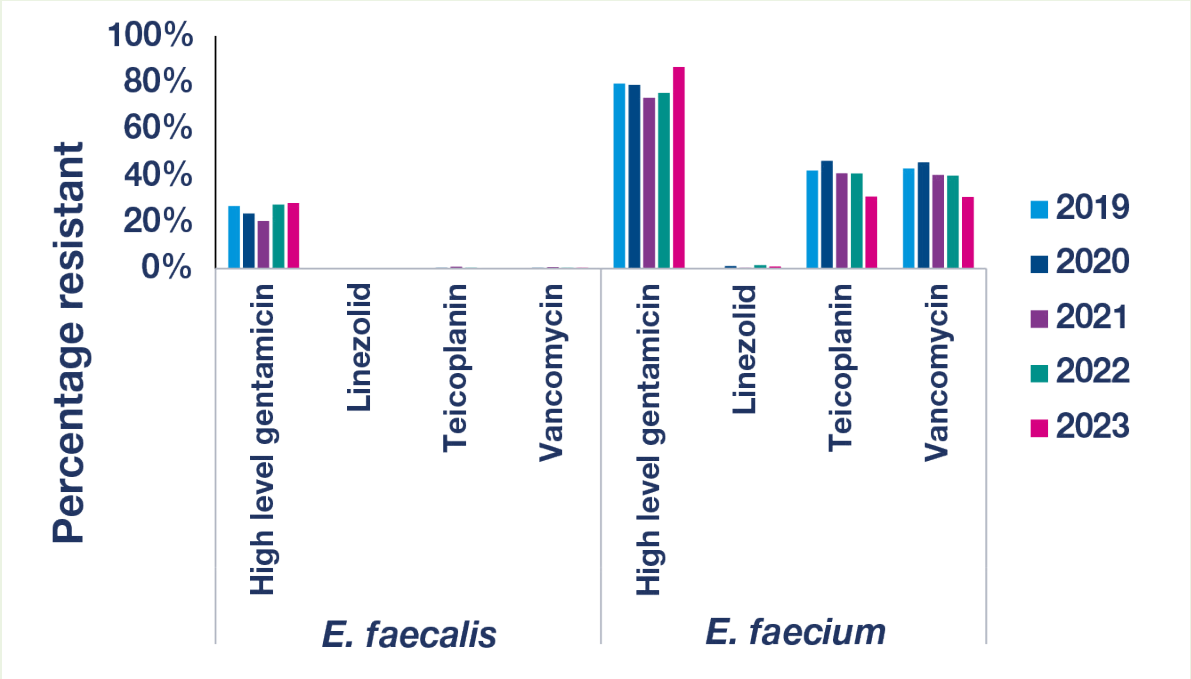
AMR in *E. faecium*

In **2023**, **vancomycin resistance** was reported in **30.8%** of ***E. faecium*** blood isolates.

Over the last five years, teicoplanin and **vancomycin resistance** has **decreased**.

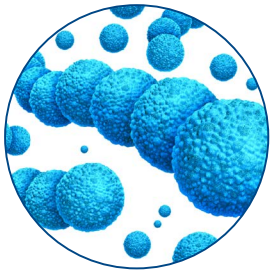
In ***E. faecium*** blood isolates between **2022** and **2023**:

- **resistance** to **high level gentamicin** has **increased**.
- **teicoplanin resistance** has **decreased**.
- **vancomycin resistance** has **remained stable**.
- **linezolid resistance** has **remained low**.



For more information on AMR in enterococcal bacteraemia see **Supplementary Data**.

Streptococcus pyogenes (Group A *Streptococcus*) bacteraemia

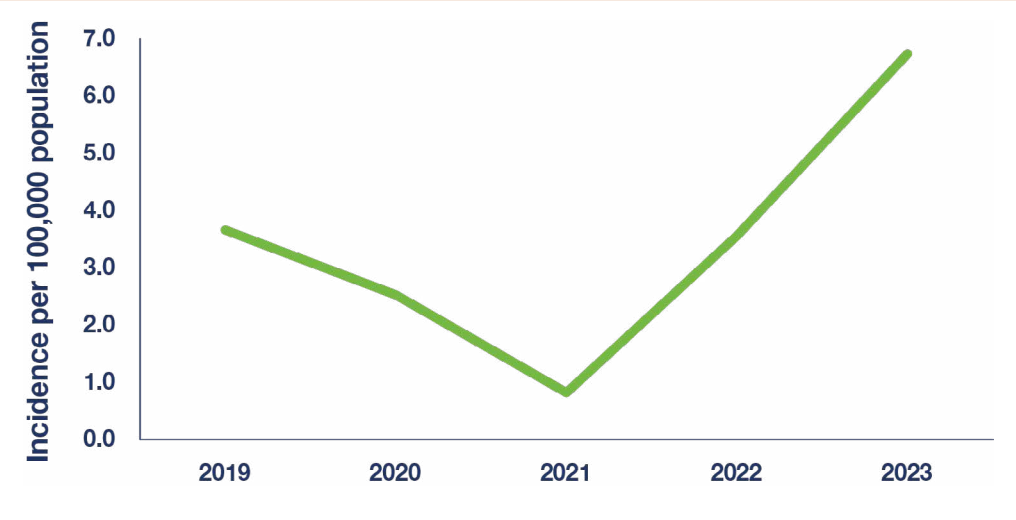


Streptococcus pyogenes (Group A *Streptococcus*) is a major pathogen, particularly for children. It causes diseases such as erysipelas, tonsillitis, scarlet fever, rheumatic fever, and glomerulonephritis.

There was a **UK-wide increase** in reports of scarlet fever and invasive Group A *Streptococcus* (iGAS) in late 2022 into spring 2023.

In **2023**, the annual ***Streptococcus pyogenes* bacteraemia incidence** was **6.7** per 100,000 population.

This was **89.2% higher** than in **2022** and **84.0% higher** than in **2019**.



AMR in *Streptococcus pyogenes* blood isolates:

- **16.7% resistant** to **tetracycline/doxycycline** in **2023.** This was **lower** compared to **2022** and **2019.**
- **4.7% resistant** to **clindamycin** in **2023.** This **remained stable** compared to **2022** and **2019.**
- **6.7% resistant** to **macrolides** (erythromycin/clarithromycin/azithromycin) in **2023.** This **remained stable** compared to **2022** but was **lower** compared to **2019.**
- **no resistance** to **penicillin** has been reported.

For information on AMR in Gram-negative organisms see **Supplementary Data**.
For further information on Discovery Dashboards see **Public Health Scotland**.

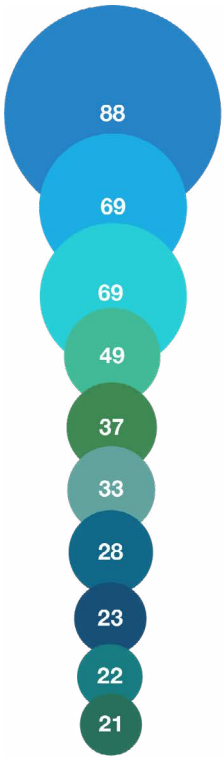
Unusual phenotypes

An unusual phenotype is an instance of unexpected AMR in an organism. ARHAI Scotland monitor unusual phenotypes, as per **Appendix 13** of the **National Infection Prevention and Control Manual**, to enable a timely scientific and public health response to potential emerging AMR issues. This informs infection control practices and appropriate therapy and is critical to contain the development and spread of resistance. Additionally, ARHAI Scotland communicate any identified issues with other public health bodies as necessary.

Local monitoring ensures that microbiology clinicians, infection prevention and control teams (IPCTs), health protection teams (HPTs) and AMTs, as appropriate, are aware of each identified case as per local protocols.

In **2023**, **592** instances of **unusual phenotypes** were reported through the **AMR Early Warning System**.

The **ten most frequently reported** unusual phenotypes were:



- meropenem resistant Enterobacterales
- meropenem/imipenem/ceftazidime/piperacillin-tazobactam resistant *Pseudomonas aeruginosa*
- ceftazidime-avibactam resistant Enterobacterales
- cefotaxime sensitive at increased dose *Streptococcus pneumoniae*
- ceftolozane-tazobactam resistant *Pseudomonas aeruginosa*
- ceftriaxone sensitive at increased dose *Streptococcus pneumoniae*
- high level penicillin resistant *Streptococcus pneumoniae* (MIC > 2 mg/L)
- colistin resistant Enterobacterales
- imipenem resistant *Acinetobacter* species
- ceftriaxone resistant *Haemophilus influenzae*

In August 2023, ARHAI issued a briefing note in response to a small number of cases of the emerging AMR fungal pathogen, *Candida auris*, in Scottish hospitals. This included provision of key information and actions relating to the detection and management of patients with *C. auris* in acute care settings.

ARHAI Scotland will continue to monitor unusual AMR incidents throughout 2024.

For further information on unusual phenotypes, including those that are less frequently reported, see **Supplementary Data**.

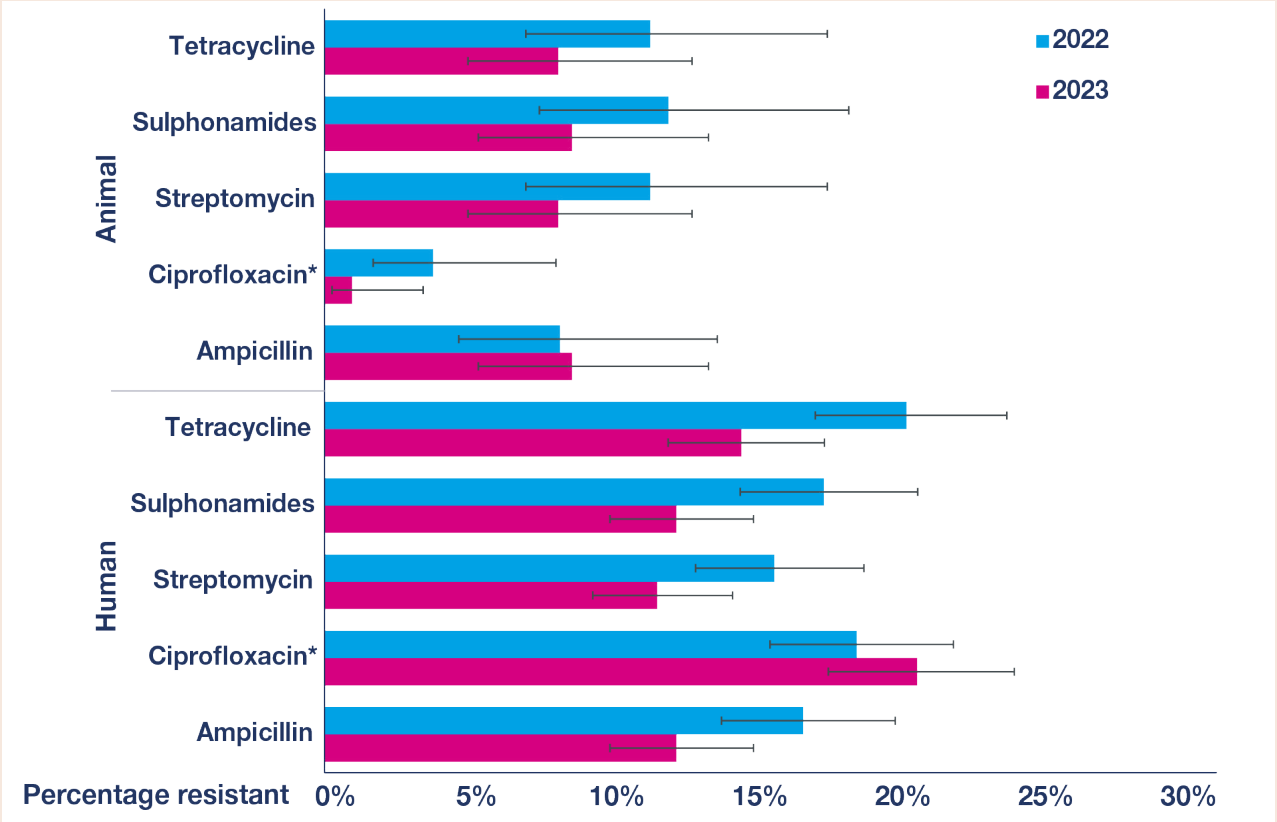
Antimicrobial resistance in *Salmonella*

Salmonella is a Gram-negative bacterium, ubiquitous in nature and a common cause of gastrointestinal illness in humans. *Salmonella* is usually a self-limiting infection and treatment with antibiotics is not routinely recommended. However, in some individuals, antimicrobial therapy may be required, particularly for severe or extraintestinal infections.

Salmonella is a zoonosis - a wide range of domestic and wild animals can act as a reservoir, including cattle, sheep, pigs, poultry, reptiles and household pets. Infected animals are often asymptomatic. *Salmonella* is notifiable in humans and a reportable animal pathogen in the UK.

In animals, resistance to key antibiotics **remained stable** between **2022** and **2023**.

In humans, resistance to ampicillin, ciprofloxacin and streptomycin remained stable between 2022 and 2023. Resistance to tetracycline and sulphonamides decreased between 2022 and 2023.



*includes mutations and acquired genes associated with reduced susceptibility above the *Salmonella* specific breakpoint of greater than 0.06mg/L as recommended by EUCAST, Jan 2024.

For information on antimicrobial resistance in *Salmonella* from humans and animals see **Supplementary Data**.

Antimicrobial resistance in animals

Antimicrobial resistance in veterinary clinical isolates from livestock

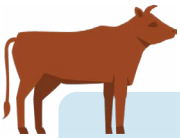
For 2023, detailed information on AMR in veterinary clinical isolates from livestock species are presented in **Supplementary Data**. These data derive from clinical specimens submitted to the farm animal diagnostic services offered by Scotland's Rural College (SRUC) Veterinary Services. These samples are tested on a 'charged for' basis to inform private veterinary treatment of diseased animals. There is a cost to the animal keeper that affects the submission of samples to these services.

The primary purpose of screening for AMR is to inform veterinary treatment and isolates from animals are tested against a panel of antimicrobials relevant for that purpose at, where they exist, species-relevant clinical breakpoints.

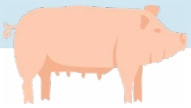
The micro-organisms included, such as *Staphylococcus* species, *Streptococcus* species, Pasteurellaceae and *E. coli* are selected based both on their prevalence among all submissions, i.e. their importance as causes of animal morbidity, as well as, in some cases, their similarity to micro-organisms that cause morbidity in humans.

Antimicrobial resistance in *E. coli* isolates from healthy livestock

In addition to diagnostic isolates, *E. coli* collected from enteric samples of healthy animals are tested as a measure of the background resistance in livestock entering the food chain. This is undertaken in collaboration with Food Standards Scotland monitoring AMR in *E. coli* from cattle, sheep, pigs and poultry presenting at abattoirs in Scotland for slaughter for human consumption. The antibiotics tested for resistance were selected for their relevance for human treatment, rather than veterinary practice.



Proportions of antimicrobial resistance to key antibiotics in *E. coli* isolates from pigs, poultry, sheep and cattle over the last five years are presented in the **Supplementary Data**.



Amongst high priority critically important antimicrobials (HP-CIAs), in 2023:

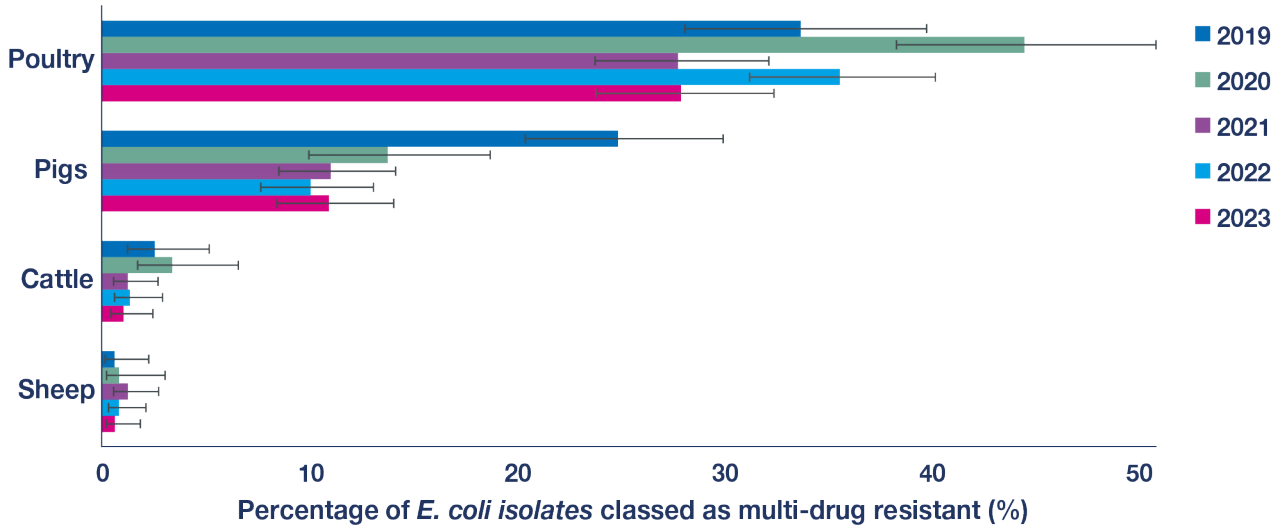
Ciprofloxacin (fluoroquinolone) **resistance decreased** in poultry and was detected from **3.6%** (15 of 415 tested) of isolates compared to **14.3%** (62 of 435 tested) in **2022**.

Resistance to **ciprofloxacin** was detected in a **single** isolate from pigs (0.2% of 474 tested) and **a single** isolate from **cattle** (0.2% of 468 tested).

Resistance to **third generation cephalosporins** was detected in **a single** isolate from **pigs** (0.2% of 474 tested).

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

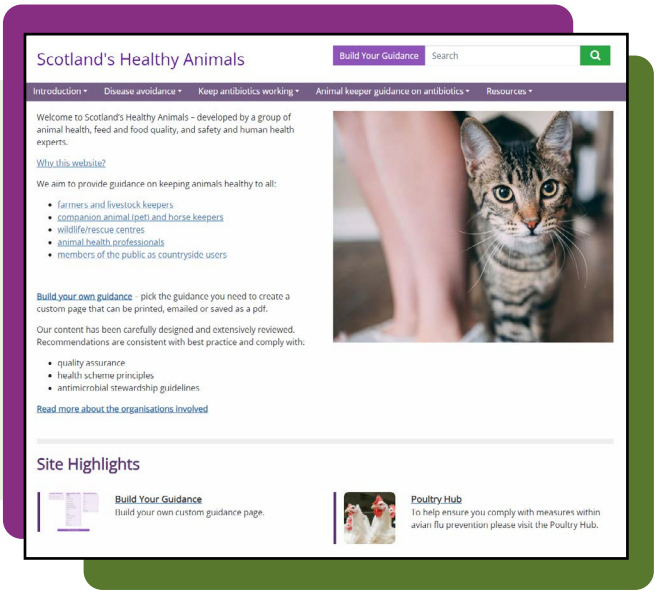
The percentage of multi drug resistant (MDR) *E. coli* isolates reported was **higher** in **poultry and pigs** than in **cattle and sheep**, where MDR remains low.



For information on AMR in *E. coli* from healthy animals see **Supplementary Data**.

Scotland's Healthy Animals Website

Guidance on keeping animals healthy and antimicrobial stewardship for all animal sectors can be found on the **Scotland's Healthy Animals Website**.



Antimicrobial resistance in the environment

Minimising the spread of AMR through the environment remains a UK priority and the UK's five-year NAP sets out the ambitions in this area. The environment has long been recognised as a dispersal route and reservoir of resistant pathogens, and as an arena for the evolution of resistance. Additionally, environmental AMR monitoring can serve as an early warning system for the presence of AMR pathogenic bacteria of public health importance. The Scottish Environment Protection Agency (SEPA) gathers intelligence to support the environmental AMR ambition in the NAP.

SEPA analyses water samples for the presence and abundance of *E. coli* and intestinal enterococci at Scotland's designated bathing water sites during the bathing season (June to mid-September). Since 2018, SEPA has also been testing and reporting on the levels of cefotaxime resistant *E. coli* in bathing water samples and recently expanded this AMR surveillance to include vancomycin resistant enterococci (VRE) (**SEPA AMR Surveillance Portal**). SEPA has previously tested some cefotaxime resistant *E. coli* isolates from bathing waters for resistance to a wide range of clinically important antibiotics and has detected such resistance for some bathing water sites.

Pharmaceutical pollution is a major global One Health problem with significant impacts on ecosystems, wildlife, people and the economy and it exacerbates the spread of AMR in the environment. SEPA, as a member of the **One Health Breakthrough Partnership**, is using a One Health approach to address pharmaceutical pollution through innovative upstream interventions (such as social and eco-directed prescribing) and to help reduce the input and impacts of human pharmaceuticals on Scotland's water environment.

List of Abbreviations and Acronyms

AMR	Antimicrobial Resistance
AMS	Antimicrobial Stewardship
AMT	Antimicrobial Management Team
AMU	Antimicrobial Use
ARHAI Scotland	Antimicrobial Resistance and Healthcare Associated Infection Scotland
AST	Antimicrobial Susceptibility Testing
AWaRe	Access, Watch, Reserve, classification of antibiotics
BSAC	British Society for Antimicrobial Chemotherapy
C. auris	*Candida auris*
CAESAR	Central Asian and European Surveillance of Antimicrobial Resistance
CI	Confidence Interval
CHI	Community Health Index
CLSI	Clinical and Laboratory Standards Institute
COVID-19	Coronavirus disease 2019
CPE	Carbapenemase-producing Enterobacterales
CPO	Carbapenemase-producing Organism
DCVP	Data Capture Validation and Pricing
DDDs	Defined Daily Doses
E. coli	*Escherichia coli*
E. faecalis	*Enterococcus faecalis*
E. faecium	*Enterococcus faecium*
EDRIP	ECOSS Roll-out Implementation Programme
ECDC	European Centre for Disease Prevention and Control
ECOSS	Electronic Communication of Surveillance in Scotland
ESPAUR	English Surveillance Programme for Antimicrobial Utilisation and Resistance
EUCAST	European Committee on Antimicrobial Susceptibility Testing
GGC	Greater Glasgow and Clyde
GLASS	Global Antimicrobial Resistance and Use Surveillance System
GP	General Practitioner
HMUD	Hospital Medicines Utilisation Database
HP-CIA	Highest Priority Critically Important Antibiotics
HPT	Health Protection Team

iGAS	Invasive Group A *Streptococcus*
ISO	International Organization for Standardization
IMP	Imipenemase
IPCT	Infection Prevention and Control Team
ISD	Information Services Division
IV	Intravenous
K. oxytoca	*Klebsiella oxytoca*
K. pneumoniae	*Klebsiella pneumoniae*
KPC	*Klebsiella pneumoniae* Carbapenemase
MDR	Multi Drug Resistant
MIC	Minimum Inhibitory Concentration
NAP	National Action Plan
NDM	New Delhi Metallo-beta-lactamases
NHS	National Health Service
NRS	National Records of Scotland
NSS	NHS National Services Scotland
OBD	Occupied Bed Days
OXA	Oxacillinase
P. aeruginosa	*Pseudomonas aeruginosa*
PHS	Public Health Scotland
PIS	Prescribing Information System
S. aureus	*Staphylococcus aureus*
S. pneumoniae	*Streptococcus pneumoniae*
SAPG	Scottish Antimicrobial Prescribing Group
SAVSNET	Small Animal Veterinary Surveillance Network
SEPA	Scottish Environmental Protection Agency
SAMRS SmiRL	Scottish Antimicrobial Resistance Service, Scottish Microbiology Reference Laboratories
SONAAR	Scottish One Health Antimicrobial Use and Antimicrobial Resistance
SRUC	Scotland's Rural College
UK	United Kingdom
UKHSA	United Kingdom Health Security Agency
UKAS	United Kingdom Accreditation Service
UTI	Urinary Tract Infection
VIM	Verona integrin-encoded metallo-beta-lactamase
VRE	Vancomycin resistant enterococci
WGS	Whole Genome Sequencing
WHO	World Health Organization

Appendix 1 – Background information

Revisions to the surveillance

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Colistin results	2016	Antimicrobial resistance in humans	A joint European Committee on Antimicrobial Susceptibility Testing (EUCAST) and Clinical and Laboratory Standards Institute (CLSI) subcommittee issued a warning on methodological issues with regard to the antimicrobial susceptibility testing of colistin, and, as such, results have not been included within this report.
Implementation of new Biomerieux® VITEK antimicrobial susceptibility testing (AST) cards within laboratories	2020	Antimicrobial resistance in humans	Implementation of new Biomerieux® VITEK AST cards in late 2018 that test amoxicillin in combination with a fixed clavulanic acid concentration of 2 mg/L as per the EUCAST recommendations. Roll out across National Health Service (NHS) boards was variable due to laboratories depleting existing stock of older cards. This change was associated with an increase in co-amoxiclav non-susceptibility in 2019.

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Temocillin breakpoints (Enterobacterales)	2020	Antimicrobial resistance in humans	No EUCAST breakpoint available. Initially all Biomerieux® VITEKs used the British Society for Antimicrobial Chemotherapy (BSAC) legacy urinary tract infection breakpoint of 16. NHS Greater Glasgow and Clyde (GGC) moved to systemic breakpoint of 8 in ~2015. Other NHS boards moved variably up until end 2017. NHS GGC and some others retained an 'I' category (minimum inhibitory concentration 16) up until October 2019 when all moved to S<8 and R>8.
Change to episode based reporting for antimicrobial susceptibility data	2020	Antimicrobial resistance in humans	Data processing antimicrobial susceptibility data: For bacteraemias and bacteriurias, only the first isolate (of one specific organism per rolling 14-day period for blood and per rolling 30-day period for urine) is reported as a case. This is equivalent to one episode of infection. The most complete or most resistant AST result during each episode is reported for each case. Where more than one organism was present in a sample deduplication was carried out separately for each organism.

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Implementation of v_11.0 EUCAST breakpoints	2021	Antimicrobial resistance in humans	Changes can be accessed **here**.
Change to ceftazidime resistance and non-susceptibility figures	2021	Antimicrobial resistance in humans	Due to an incorrect mapping of antibiotic code in Electronic Communication of Surveillance in Scotland (ECOSS), ceftazidime was being incorrectly reported as cefradine. This was limited to one NHS board but accounted for a significant number of results since 2007. This has been corrected and amended retrospectively for data included in this report.
Implementation of v_12.0 EUCAST breakpoints	2022	Antimicrobial resistance in humans and antimicrobial resistance in *Escherichia coli* isolates from healthy livestock	Changes can be accessed **here**. Breakpoints are generally lower in the EUCAST breakpoint table version 12.0. Exceptions to this are trimethoprim for both Enterobacterales and *Staphylococcus aureus* and azithromycin for *S. aureus* only, where the breakpoint has increased. A reduction in a breakpoint will result in an increase in the number of isolates falling into the resistant category. Conversely, an increased breakpoint will result in a reduction in the numbers in the resistant category.

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
New definitions of Sensitive, Intermediate and Resistant antimicrobial resistance categories	2022	Antimicrobial resistance in humans and antimicrobial resistance in animals	Previously, intermediate and resistant isolates were grouped and reported as one category: non-susceptible isolates. Antimicrobial resistance results included in this report are percentage resistant as opposed to percentage non-susceptible. See **EUCAST New S I and R**
Carbapenemase-producing organisms	2022	Antimicrobial resistance in humans	Mixed cultures with a positive enzyme are now excluded from analysis. This has been corrected and amended retrospectively for data included in this report.
Change to de-duplication method for AST data	2022	Antimicrobial resistance in humans	Changes were made to the data processing to improve the de-duplication method and better identify isolates with the most complete and most resistant AST results. This has been corrected and amended retrospectively for data included in this report.

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Fosfomycin results	2022	Antimicrobial resistance in humans	EUCAST have noted that testing for fosfomycin susceptibility in *E. coli* urinary isolates using VITEK 2 may lead to errors, and recommend that this method of testing is not used (see **here** for further details). The majority of laboratories in NHS Scotland use VITEK 2 and therefore AST results for fosfomycin may be unreliable. Consequently, fosfomycin resistance is not included in this report.
Human Antimicrobial use (AMU) – antibiotic exclusions	2023	Antimicrobial use in humans	The antibiotic Rifaximin has been excluded from the AMU data.
Human AMU – hospital exclusions	2023	Antimicrobial use in humans	National action plan (NAP) Target 3 has been amended to cover acute hospitals

Description of Revision	First report revision applied	Report section(s) revision applies to	Rational for revision
Human AMU – Data Collection	2023	Antimicrobial use in humans	The contractor payment system used by NHS Scotland for producing payment schedules for pharmacies, dispensing doctors, and appliance suppliers on behalf of NHS Boards has been replaced as of May 2023. The system, DCVP (Data Capture Validation and Pricing), was the primary data source for the Prescribing Information System (PIS) which is where Primary Care AMU data are obtained. DCVP was outdated, with many unsupported components and a high risk of system failure. Its replacement is a digital pharmacy payment system with improved automation, fully supported software components and the flexibility to adapt to a paperless prescribing future. The new pharmacy payments system is called New DCVP. The data included in the Primary Care AMU sections of this report have been obtained using this new system.

Appendix 2 – Metadata

Publication title

Scottish One Health Antimicrobial Use and Antimicrobial Resistance in 2023 (SONAAR report, 2023)

Description

This annual report provides data relating to antimicrobial use (AMU) and antimicrobial resistance (AMR) in Scotland during 2023.

Theme

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

Topic

Antimicrobial use and resistance in humans and animals.

Format

Online resource (PDF).

Data source(s)

Antimicrobial use in humans

Antibiotic use in primary care: Prescribing Information System (PIS), Public Health Scotland (PHS) and NHS National Services Scotland (NSS).

Population denominator data: Mid-year population projections for Scotland, National Records of Scotland (NRS) population estimates.

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

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

Antimicrobial use in animals

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

Antimicrobial resistance in humans

Bacteraemia:
Case data: ECOSS.

Population denominator data: Mid-year population projections for Scotland, NRS population estimates.

UK AMR National Action Plan (NAP) Target estimated infections:
Electronic Communication of Surveillance in Scotland (ECOSS) and ECOSS Enhanced Surveillance Web Tool.

Urinary tract infections caused by *Escherichia coli*: ECOSS.

Carbapenemase-producing organisms:

Case data: ECOSS and the Scottish Antimicrobial Resistance Service, Scottish Microbiology Reference Laboratories (SAMRS SMiRL, Glasgow).

Population denominator data: Mid-year population projections for Scotland, NRS population estimates.

Unusual phenotypes: ECOSS.

Antimicrobial resistance in *Salmonella*: SAMRS SMiRL via PHS.

Antimicrobial resistance in animals: Scotland's Rural College (SRUC) Veterinary Services.

Antimicrobial resistance in the environment: N/A

Date that data are acquired

Antimicrobial use in humans

Antibiotic use in primary care:

Patient-based analysis: 06/09/2024

Urinary tract infections analysis: 06/08/2024

Primary care trend data: 24/07/2024

Primary care duration of course analysis: 04/07/2024

Primary care antifungal analysis: 20/08/2024

Population denominator data: Mid-year population projections for Scotland, NRS population estimates: 07/06/2023

Antibiotic use in secondary care:

Secondary care trend analysis: 24/07/2024

Secondary care antifungal analysis: 23/08/2024
Healthcare denominator data: Total occupied bed days (OBDs), Sum of OBDs for all hospitals in numerator: 24/07/2024

Antimicrobial use in companion animals: 30/07/2024

Antimicrobial resistance in humans

Bacteraemia:

Case data: 08/04/2024

Population denominator data: Mid-year population projections for Scotland: 07/06/2023

UK AMR NAP Target estimated infections: 08/04/2024

Urinary tract infections caused by *Escherichia coli*: 02/04/2024

Carbapenemase-producing organisms:

Case data: 08/04/2024

Population denominator data: Mid-year population projections for Scotland: 07/06/2023

Unusual phenotypes: 30/08/2024

Antimicrobial resistance in *Salmonella*: 01/07/2024

Antimicrobial resistance in animals

Antimicrobial resistance in veterinary clinical isolates from livestock: 05/09/2024

Antimicrobial resistance in *Escherichia coli* isolates from healthy livestock: 05/06/2024

Antimicrobial resistance in the environment: N/A

Release date

19 November 2024

Frequency

Annual

Timeframe of data and timeliness

The latest iteration of data are to 31 December 2023, therefore 11 months in arrears.

Antimicrobial use in humans: Data are for 2013 to 2023 and are timely for this report.

Antimicrobial use in companion animals: Data are for 2019 to 2023 and are timely for this report.

Antimicrobial resistance in humans

Bacteraemia: Data are for 2019 to 2023 and are timely for this report.

UK AMR NAP Target estimated infections: Data are for 2018 to 2023 and are timely for this report.

Urinary tract infections caused by *Escherichia coli*: Data are for 2022 and 2023 and are timely for this report.

Carbapenemase-producing organisms: Data are for 2019 to 2023 and are timely for this report.

Unusual phenotypes: Data are for 2023 and are timely for this report.

Antimicrobial resistance in *Salmonella*: Data are for 2021 to 2023 and timely for this report.

Antimicrobial resistance in animals: Data are for 2019 to 2023 and are timely for this report.

Antimicrobial resistance in the environment: N/A

Continuity of data

Antimicrobial use in humans: Changes in healthcare activity during the COVID-19 pandemic may have affected antimicrobial use and comparison of results should be interpreted with caution.

Antimicrobial use in companion animals: The COVID-19 pandemic may have affected the level of contact between companion animals and their vets, and the number of consultations reported between 2020 and 2022. Comparison of results should be interpreted with caution.

Antimicrobial resistance in humans:

Throughout 2022, the majority of Scottish National Health Service (NHS) diagnostic laboratories, on a phased basis, changed from version 9.0 of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoint table to version 12.0. Breakpoints are generally lower in the EUCAST breakpoint table version 12.0.

Exceptions to this are trimethoprim for both Enterobacterales and *Staphylococcus aureus (S. aureus)* and azithromycin for *S. aureus* only, where the breakpoint has increased. A reduction in a breakpoint will result in an increase in the number of isolates falling into the resistant category. Conversely, an increased breakpoint will result in a reduction in the numbers in the resistant category. This must be considered when interpreting results for this report.

Prior to the **2022 SONAAR Annual Report**, intermediate and resistant isolates were grouped and reported as one category: non-susceptible isolates. AMR results included in this report are percentage resistant as opposed to percentage non-susceptible, and therefore not comparable with SONAAR reports published in earlier years.

Changes in healthcare activity and patient populations during the COVID-19 pandemic may have affected the epidemiology of infections included in this report and comparison of results should be interpreted with caution.

Antimicrobial resistance in *Salmonella*:

Changes in healthcare activity, patient populations and contact between animals and their vets during the COVID-19 pandemic may have affected the epidemiology of *Salmonella* and comparison of results should be interpreted with caution.

Antimicrobial resistance in animals:

The COVID-19 pandemic may have affected the level of contact between animals and their vets between 2020 and 2022. Comparison of results should be interpreted with caution.

Antimicrobial resistance in the environment: N/A

Revisions statement

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

Revisions relevant to this publication

National Records of Scotland (NRS) mid-year population estimates

Updated to mid-2022 population estimates for 2022 (Q1-Q4) and 2023 (Q1-Q4) as published by NRS.

Antimicrobial use in humans: None

Antimicrobial use in companion animals: None

Antimicrobial resistance in humans

Previously, intermediate and resistant isolates, as defined by EUCAST, were grouped and reported as one category: non-susceptible isolates. Following a definition update from EUCAST, and to align with **English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) annual report**, AMR results included in this report are percentage resistant as opposed to percentage non-susceptible. The new methods have been applied to historic data to allow year-on-year trend analyses using the same definitions.

Bacteraemia: None.

UK AMR NAP Target estimated infections: None.

Urinary tract infections caused by *Escherichia coli*: None.

Carbapenemase-producing organisms: None.

Antimicrobial resistance in *Salmonella*:

None.

Antimicrobial resistance in animals:

Retrospective amendments were made to data processing to improve the capture and identification of isolate Antimicrobial Susceptibility Testing (AST) results.

Antimicrobial resistance in the environment: N/A

Concepts and definitions

Statistical significance: Please note where an increase or decrease is stated in this report this refers to a statistical change. Where a trend is referred to as stable, there has been no statistically significant increase or decrease. Statistical significance has been determined by a p-value of less than (<) 0.05. Due to the number of tests being done at the same time a Bonferroni correction has been applied and the p-values adjusted to reflect the number of tests undertaken for each organism.

In order to keep the amount of multiple testing to a minimum, only organism and drug combinations with enough cases each year have been tested.

Confidence Intervals: Confidence intervals (95% CI) for proportions were calculated to indicate robustness of the proportions presented. Where a 95% CI has been quoted or displayed in a figure as an error bar around a percentage, the method used is the Wilson Score.

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

Year to Year Comparisons: The current calendar year 2023 is compared to the previous calendar year 2022 using two-sided z-tests for proportions and rate ratio tests (using Poisson counts) for rates. A resulting p-value of less than 0.05 (or Bonferroni-adjusted threshold) was deemed statistically significant to determine an increase or decrease relative to the previous year.

Five Year Trends: Rates and proportions over the past five years are modelled using Poisson regression and negative binomial regression respectively. This is performed to determine the presence of a significant upwards or downwards linear trend in the changing rate or proportion, and the corresponding rate of change of the best-fit gradient over the past five years from 2019 to 2023.

Where a five year trend increase or decrease has been reported, this represents a significant linear trend over the past five years. Where no five year trend increases or decreases have been detected, these are reported as stable. When a trend over the past five years has been detected, but the trend is not linear, a direct year-to-year comparison between 2019 and 2023 has been made.

For antimicrobial susceptibility testing results where revisions were made to the EUCAST clinical breakpoints during the time period, five year trend analyses have not been reported.

Five year trends of antimicrobial susceptibility testing results for *E. coli* urine isolates were not reported due to historic differences in reporting of urine isolates into ECOSS across NHS Boards.

Antimicrobial use in humans

Prescribing data: details available from Public Health Scotland **overview of prescribing data**.

Population estimates: details available from the **National Records of Scotland Mid-Year Population Estimates**.

Occupied bed days: details available in Public Health Scotland **ISD(S)1 data manual**.

Defined Daily Doses (DDDs), World Health Organization (WHO): details available from the **ATC/DDD Index**.

Adapted Access, Watch, Reserve (AWaRe) classification of antibiotics: Budd, E., et al. (2019) **Adaptation of the WHO Essential Medicines List for national antibiotic stewardship policy in England: being AWaRe**. Journal of Antimicrobial Chemotherapy, Volume 74 (Issue 11), pages 3384-3389.

Unless otherwise stated Primary Care figures exclude Dental (GP14) Prescription Forms.

Primary care prescribing information sourced from PIS is linked to patient Community Health Index (CHI) numbers. Using patient CHI numbers, it is possible to analyse demographic information on patients prescribed antibiotics such as age and gender. Patients resident in Scotland have a unique CHI number meaning it is also possible to count numbers of distinct patients receiving a particular treatment or investigate prescribing patterns for particular individuals over time. From 2009 onwards, the majority of prescriptions can be linked to a valid CHI number, however CHI capture rates can vary by drug, geographical area or prescriber type, with GPs having better capture rates than other prescriber types. When interpreting trends in patient counts over time, the underlying CHI capture rate must also be considered. In the supplementary data for this report, where patient level data is used, the relevant CHI capture rates are also presented. It is difficult to identify with certainty how much impact increasing CHI completeness has on the number of patients identified, but the evidence available suggests that the impact is small when considering the scale of change in CHI completeness presented in this report and this should not generally be significantly affecting trends in patient counts.

Parenteral antibiotic DDDs are used to monitor use of intravenous antibiotics.

UK National Action Plan Targets for antimicrobial use:

The UK AMR National Action Plan (NAP) 2019-2024 included targets on antibiotic use to act as a focus for improvement activity to preserve the effectiveness of the currently available antibiotics. The targets were to:

- Reduce UK antibiotic use in humans by 15% by 2024
- Reduce UK antibiotic use in the community by 25% by 2024
- Reduce use of Watch and Reserve antibiotics in acute hospitals by 10% by 2024

Further information available in the **UK 5-year action plan for antimicrobial resistance 2019 to 2024**.

Antimicrobial use in companion animals

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

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

For further detail visit the **SAVSNET website**.

Description of the methods used by SAVSNET to capture electronic health records:

Sánchez-Vizcaíno, F., et al. (2015) **Small animal disease surveillance**. Veterinary Record, Volume 177 (Issue 23), pages 591-594.

D.A. Singleton, et al. (2017) **Patterns of antimicrobial agent prescription in a sentinel population of canine and feline veterinary practices in the United Kingdom**. The Veterinary Journal, Volume 224, pages 18-24.

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

D.A. Singleton, et al. (2019) **Small animal disease surveillance: gastrointestinal disease, antibacterial prescription and *Tritrichomonas* foetus**. Veterinary Record, Volume 184 (Issue 7), pages 211-216

D.A. Singleton, et al. (2019) **Small animal disease surveillance 2019: pruritus, pharmacosurveillance, skin tumours and flea infestations**. Veterinary Record, Volume 185 (Issue 15), pages 470-475.

D.A. Singleton, et al. (2019) **Small animal disease surveillance 2019: respiratory disease, antibiotic prescription, and canine infectious respiratory disease complex**. Veterinary Record, Volume 184 (Issue 21), pages 640-645.

Antimicrobial resistance in humans

Case definitions:

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

A new case of bacteraemia is a patient from whom an organism has been isolated from the patient's blood, and who has not previously had the same organism isolated from blood within a 14-day period (i.e. 14 days from date last positive sample obtained). The most complete then most resistant AST result during each episode is reported for each case.

A new case of bacteriuria (referred to in this report as 'episodes isolated from urine') is a patient from whom an organism has been isolated from the patient's urine, and who has not previously had the same organism isolated from urine within a 30-day period (i.e. 30 days from date last positive sample obtained). The most complete then most resistant AST result during each episode is reported for each case.

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

With the exception of *Escherichia coli* bacteraemia and *Staphylococcus* aureus bacteraemia, all human bacteraemia data are based only on positive blood results extracted from ECOSS and are not validated cases. *Escherichia coli* bacteraemia and *Staphylococcus aureus* bacteraemia data use validated data collected as part of mandatory surveillance programme as detailed in the **Protocol for National Enhanced Surveillance of Bacteraemia**.

Please note that bacteriuria (bacteria present in urine) is used as a proxy for urinary tract infection (UTI) and not all cases reported will be validated cases of UTI. As part of the **NHS Pharmacy First Scotland** service, community pharmacists have the ability to supply via patient group direction trimethoprim or nitrofurantoin for uncomplicated UTIs in females aged 16 to 65. This service has been available in all community pharmacies since August 2020 and is likely to have had an impact on the number of urine samples being referred to laboratories since females with uncomplicated UTIs can be treated by pharmacists without attending their General Practitioner.

A new case of CPO is a patient from whom an organism-carbapenemase enzyme gene combination has been identified from a clinical or screening specimen, and who has not previously had the same organism-carbapenemase enzyme gene combination identified within the same calendar year.

Incidence rates were calculated as follows:

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

Population estimates: details available from the **National Records of Scotland Mid-Year Population Estimates**.

Percentage resistance:

Resistance is defined as isolates reported as resistant (R).

Percentage resistant = resistant isolates divided by the total number of isolates tested multiplied by 100.

Antimicrobial resistance burden:

The burden of antimicrobial resistant bacteraemia is estimated for *Escherichia coli*, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Acinetobacter* species, *Pseudomonas aeruginosa*, *Enterococcus faecium*, *Enterococcus faecalis*, *Staphylococcus aureus* and *Streptococcus pneumoniae* bacteraemia cases based on the percentage of organisms resistant (R) to at least one key antibiotic (see Table 1: Key organism and antibiotic combinations for burden of antimicrobial resistant bacteraemia).

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

Table 1: Key organism and antibiotic combinations for burden of antimicrobial resistant bacteraemia.

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

The total number of antimicrobial resistant infections was calculated based on a methodology published by the European Centre for Disease Prevention and Control (ECDC) for estimating incidence of antimicrobial-resistant bacterial infections (A. Cassini et al. (2019) **Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis**. Lancet Infectious Diseases, Volume 19, pages 56-66.).

This method calculates the ratio of antimicrobial resistant bloodstream infections to antimicrobial resistant surgical site infections, urinary tract infections, respiratory infections and other infections, using point prevalence survey data and bloodstream infection data reported to ECDC. Further details can be found in the ECDC publication. The ratios calculated for the UK were applied to the estimated number of antimicrobial resistant bacteraemia in Scotland to give an estimate of the total number of antimicrobial resistant infections. The organism – antibiotic combinations included in this calculation are listed in Table 2 below, and are the specified set of drug resistant infections used in monitoring the UK AMR national action plan (NAP) ambition to reduce the incidence of drug resistant infections by 10% by 2024.

Table 2: Key organisms and antibiotics for burden of antimicrobial resistant infections as measured in the 2019-2024 UK AMR NAP.

Organism(s)	Key antibiotic(s)
Escherichia coli and *Klebsiella pneumoniae*	Carbapenems (imipenem, meropenem or ertapenem) Third generation cephalosporins (ceftazidime, cefotaxime or ceftriaxone), and not resistant to carbapenems
Acinetobacter species	Carbapenems (imipenem or meropenem) Aminoglycosides (amikacin or gentamicin) and ciprofloxacin, but not resistant carbapenems
Pseudomonas aeruginosa	Carbapenems (imipenem or meropenem) Three or more antimicrobial groups (aminoglycosides (amikacin, gentamicin), piperacillin-tazobactam (Tazocin), ciprofloxacin, ceftazidime), but not resistant to carbapenems
Enterococcus faecium and *Enterococcus faecalis*	Vancomycin
Staphylococcus aureus	Meticillin
Streptococcus pneumoniae	Penicillin and macrolides (erythromycin, azithromycin, clarithromycin) Penicillin, but not resistant to macrolides

Urinary tract infections caused by *Escherichia coli*:

EUCAST have noted that testing for fosfomycin susceptibility in *E. coli* urinary isolates using VITEK 2 may lead to errors, and recommend that this method of testing is not used (see here for further details). The majority of laboratories in NHS Scotland use VITEK 2 and therefore AST results for fosfomycin may be unreliable. Consequently, fosfomycin resistance is not included in this report (see **Appendix 1**).

Carbapenemase-producing organisms:

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

Further detail on case definitions can be accessed from the **Toolkit for the early detection, management and control of carbapenemase-producing Enterobacteriaceae in Scottish acute settings**.

Unusual phenotypes:

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

Definitions of an unusual phenotype can be accessed from **EUCAST**.

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

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

An instance of an unusual phenotype was considered as the first isolate of one specific organism per patient per calendar year. Where more than one organism was present in a sample, deduplication was carried out separately for each organism.

Antimicrobial resistance in *Salmonella*

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

Salmonella is notifiable in humans and a reportable animal pathogen in the UK. All medical diagnostic laboratories are required to forward suspect isolates from humans to the SAMRS SMiRL which is responsible for testing antimicrobial susceptibility in *Salmonella*. All veterinary diagnostic laboratories isolating *Salmonella* from livestock species and dogs are also required to send suspect isolates for confirmation and typing to the SAMRS SMiRL. The submission of animal samples is affected by the willingness of an animal keeper to pay the costs of laboratory testing to inform treatment, in addition to the clinical presentation in the affected animal(s). Whole genome sequencing (WGS) was introduced into routine use in the SAMRS SMiRL in late 2017 for the identification and characterisation of *Salmonella* isolates.

Following a review of published reports and an extensive validation confirming the high degree of correlation observed between the two approaches, the in *silico* prediction of AMR phenotype from WGS was introduced in January 2020. The predictive tools in use allow the identification of many individual AMR genes. The availability of data from isolates from different source populations (humans and animals) which have undergone the same processing by the same laboratory offers an opportunity to monitor the trends in resistance and identify epidemiological links in these populations.

Antimicrobial resistance in animals

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

Streptococcus species can be important pathogens or opportunist colonisers of livestock species, with the potential to cause severe disease of the skin, respiratory tract, body cavities, wounds and urinary tract. Some species, including *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, and *Streptococcus suis*, are also recognised in human infections.

Pasteurellaceae are important causes of potentially severe respiratory and soft tissue infections in livestock animals. In livestock animals, high levels of morbidity and mortality can result with consequential significant economic losses.

E. coli are a major constituent of the normal faecal flora of humans and warm-blooded animals. However, some strains can cause intestinal and extraintestinal disease.

Antimicrobial resistance in veterinary clinical isolates from livestock:

Data presented here represent the percentage of resistant isolates over all tested isolates. The percentage of multi drug resistant isolates, defined as isolates resistant to three or more antimicrobial classes, is also presented. These data represent a non-random sample of veterinary practices and veterinary isolates, based on voluntary submission of data to SRUC.

The data from veterinary clinical isolates are subject to a number of important biases. Unlike the clinical samples in humans in Scotland, the samples are tested on a 'charged for' basis to inform private veterinary treatment of diseased animals. There is a cost to the animal keeper that affects the submission of samples to these services. In addition, the primary purpose of screening for AMR is to inform veterinary treatment and they are tested against a panel of antimicrobials relevant for that purpose at, where they exist, species-relevant clinical breakpoints, based on British Society for Antimicrobial Chemotherapy (BSAC) breakpoints. Interpretation of these data in terms of their relevance to public health is challenging beyond the notion of evidence of impact of a selection pressure existing in another compartment of the ecosystem that humans share closely with animals.

Antimicrobial resistance in *Escherichia coli* isolates from healthy livestock:

Data presented here represent the percentage of resistant isolates over all tested isolates. These isolates are from healthy livestock animals and are tested against a panel of antimicrobials, and at breakpoints, relevant to human clinical isolates. The percentage of multi drug resistant isolates, defined as isolates resistant to three or more antimicrobial classes, is also presented.

Breakpoints for AST in *E. coli* isolates from healthy livestock are provided by SRUC and are aligned with EUCAST breakpoints, except tetracycline which uses the Clinical and Laboratory Standards Institute (CLSI) breakpoint value. EUCAST breakpoints are applied to healthy livestock isolates to enable relevant comparisons of resistance with isolates from humans, to human relevant antibiotics. Changes to breakpoints over time have been applied retrospectively to healthy livestock isolates to allow year-on-year comparisons.

Antimicrobial resistance in the environment: N/A

Relevance and key uses of the statistics

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

Accuracy

Antimicrobial use in humans

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

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

Antimicrobial use in companion animals: Data and analyses provided by SAVSNET from a non-random sample of veterinary practices.

Antimicrobial resistance in humans

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

UK AMR NAP Target estimated infections: The calculation of estimated infections uses data supplied by United Kingdom Accreditation Service (UKAS) accredited laboratories using standardised testing methodologies. The estimate is based on the ratio of antimicrobial resistant bloodstream infections to antimicrobial resistant surgical site infections, urinary tract infections, respiratory infections and other infections, using point prevalence survey data and bloodstream infection data reported to ECDC. Ratios calculated for the UK were applied to the estimated number of antimicrobial resistant bacteraemia in Scotland to give an estimate of the total number of antimicrobial resistant infections.

Urinary tract infections caused by *Escherichia coli*: Data supplied by UKAS accredited laboratories using standardised testing methodologies. However, it should be noted that Public Health Scotland are undertaking an ECOSS quality improvement project (ECOSS Roll-out Implementation Programme (EDRIP)) which has highlighted some inconsistent mapping and reporting of urine sample results in ECOSS. EDRIP is currently paused due to the roll out of a new laboratory information management system. Due to these data inconsistencies, it is not currently possible to report and compare incidence over time, however we do not expect this to impact the national antimicrobial resistance.

Carbapenemase-producing organisms: Data supplied by UKAS accredited laboratories using standardised testing methodologies.

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

Antimicrobial resistance in *Salmonella*: Data supplied by UKAS accredited laboratories using standardised testing methodologies. SAMRS SMiRL.

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

Antimicrobial resistance in the environment: N/A

Completeness

Antimicrobial use in humans: All data for the reporting period have been included in the analysis.

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

Antimicrobial resistance in humans

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

NAP Target estimated infections: All data for the reporting period have been included in the analysis.

Urinary tract infections caused by *Escherichia coli*: All available data within ECOSS have been included in the analysis. In 2022, it was identified that urine isolates from one NHS board had not been reported in ECOSS. Following investigation, isolates were reported from September 2022 onwards. Due to inconsistencies in data collection over time it has not been possible to report and compare incidence and AMR trends in urine isolates.

Carbapenemase-producing organisms: There were some carbapenemase-producing organism isolates where full antibiotic susceptibility testing was not carried out in 2023.

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

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

Antimicrobial resistance in animals

Antimicrobial resistance in veterinary clinical isolates from livestock: These data represent a non-random sample of veterinary practices and veterinary isolates, based on voluntary submission of data to SRUC. Isolates are derived from samples and animal carcases submitted throughout the year to Disease Surveillance Centres operated by SRUC across Scotland.

Antimicrobial resistance in *Escherichia coli* isolates from healthy livestock: Samples are collected on a monthly basis from livestock animals presenting at abattoirs in Scotland and submitted to SRUC.

Antimicrobial resistance in the environment: N/A

Comparability

Antimicrobial use in humans

The numerator for antibiotic use includes the number of WHO DDDs and is comparable to other antibiotic use surveillance programmes using this method. These data are extracted from live databases (PIS and HMUD) where historic data may be subject to slight variation.

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

ARHAI Scotland are a member of the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network and contribute AMU data to **WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS)**.

Antimicrobial use in companion animals: N/A

Antimicrobial resistance in humans

Bacteraemia:

Further details on bacteraemia in Scotland are available in the **ARHAI Scotland Annual Report**.

Further details on reports on AMR surveillance across the UK (UKHSA, PHW) are reported below, as well as from the ECDC (EARS-Net). ARHAI Scotland submit data annually to the UK AMR NAP ambitions (UKHSA), and to the WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) initiative, and ARHAI Scotland are part of the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) Network. The comparability of data across these reports should be interpreted with caution, due to differences in inclusion criteria, data definitions and availability.

UKHSA annual **English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) report**. **https://www.gov.uk/government/publications/english-surveillance-programme-antimicrobial-utilisation-and-resistance-espaur-report**

Public Health Wales annual **Antimicrobial resistance in blood cultures in Wales report**.

European Centre for Disease Prevention and Control (ECDC) **report on Antimicrobial resistance surveillance in Europe**.

AMR and prescribing data from ARHAI Scotland and UKHSA are included in the **WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) dashboard**.

Escherichia coli and *Staphylococcus aureus* bacteraemia epidemiological data are **published quarterly by ARHAI Scotland**.

ARHAI Scotland Annual report: https://www.nss.nhs.scot/publications/arhai-scotland-2023-annual-report/

Urinary tract infections caused by *Escherichia coli*:

UKHSA annual **English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) report**.

Carbapenemase-producing organisms:

UKHSA **collection on carbapenem resistance**.

ECDC **Surveillance Atlas of Infectious Diseases**.

Unusual phenotypes: N/A

Antimicrobial resistance in *Salmonella*: N/A

Antimicrobial resistance in animals

Antimicrobial resistance in veterinary clinical isolates from livestock: The primary purpose of screening for AMR is to inform veterinary treatment and isolates from animals are tested against a panel of antimicrobials relevant for that purpose at, where they exist, species-relevant clinical breakpoints.

Interpretation of these data in terms of their relevance to public health is challenging beyond the notion of evidence of impact of a selection pressure existing in another compartment of the ecosystem that humans share closely with animals.

Antimicrobial resistance in *Escherichia coli* isolates from healthy livestock: Breakpoints for AST in *E. coli* isolates from healthy livestock are provided by SRUC and are aligned with EUCAST breakpoints, except tetracycline which uses the CLSI breakpoint value. EUCAST breakpoints are applied to healthy livestock isolates to enable relevant comparisons of resistance with isolates from humans, to human relevant antibiotics. Changes to breakpoints over time have been applied retrospectively to healthy livestock isolates to allow year-on-year comparisons.

Antimicrobial resistance in the environment: N/A

Accessibility

It is the policy of NHS National Services Scotland (NSS) to make its web sites and products accessible according to published guidelines.

Coherence and clarity

Tables are accessible via the **Supplementary Data** on our website.

Value type and unit of measurement

Antimicrobial use in humans:

DDDs per 1,000 population per day (DDDs/1,000/day).
Percentage of DDDs by prescriber type (%) = count of DDDs by prescriber type / total count of DDDs.

Percentage of antibiotics use belonging to Access group (%) = count of antibiotic items belonging to Access group / total count of antibiotic items.

Count of items and number of items per 1,000 population per day (items/1,000/day).

Percentage of the Scottish population receiving at least one course of antibiotics (%) = count of individuals receiving at least one course of antibiotics / total population.

Percentage of antibiotic courses of five-day duration (%) = count of antibiotic items of five-day duration / total count of antibiotic items.

Percentage of primary care items by prescriber type (%) = count of antibiotic items by prescriber type in primary / total count of antibiotic items in primary care.

DDDs per 1,000 occupied bed days (DDDs/1,000 occupied bed days).

Percentage of antibiotics given intravenously (%) = count of DDDs for IV antibiotics / total count of antibiotic DDDs.

Antimicrobial use in companion animals:

Count of consultations and individual animals.

Percentage of consultations resulting in prescription of antimicrobials (%) = count of consultations resulting in prescription of at least one antimicrobial / total count of consultations.

Percentage of antimicrobial prescriptions that were high priority critically important antimicrobials (%) = count of antimicrobial prescriptions that were high priority critically important antimicrobials / total count of antimicrobial prescriptions.

Antimicrobial resistance in humans

Bacteraemia:

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

Percentage of resistant blood isolates (%) = count of blood isolates resistant for antibiotic/organism combination / total count of blood isolates tested for antibiotic/organism combination.

UK AMR NAP Target estimated infections:

Estimated count of antimicrobial resistant infections, calculated based on the ratio of antimicrobial resistant bloodstream infections to antimicrobial resistant surgical site infections, urinary tract infections, respiratory infections and other infections. Ratios calculated for the UK were applied to the estimated number of antimicrobial resistant bacteraemia in Scotland to give an estimate of the total number of antimicrobial resistant infections.

Urinary tract infections caused by *Escherichia coli*:

Count of cases.

Percentage of resistant urine isolates (%) = count of urine isolates resistant for antibiotic/organism combination / total count of urine isolates tested for antibiotic/organism combination.

Carbapenemase-producing organisms:

Count of cases and incidence rate (per 100,000 population).

Count of cases by enzyme type and organism.

Percentage of cases by organism (%) = count of cases by organism / total count of cases.

Unusual phenotypes:

Count of confirmed unusual phenotype instances, and count of confirmed unusual phenotype instances per organism/antibiotic combination.

Antimicrobial resistance in *Salmonella*:

Percentage of inferred phenotypic resistance from WGS by antimicrobial (%) = count of isolates with inferred phenotypic resistance / total count of tested isolates.

Antimicrobial resistance in animals

Antimicrobial resistance in veterinary clinical isolates from livestock:

Count of resistant isolates and count of all isolates tested.

Percentage of resistant isolates (%) = count of resistant isolates / total count of all isolates tested.

Antimicrobial resistance in Escherichia coli isolates from healthy livestock:

Count of resistant isolates and count of all isolates tested.

Percentage of resistant isolates (%) = count of resistant isolates / total count of all isolates tested.

Antimicrobial resistance in the environment: N/A

Disclosure
The PHS protocol on Statistical Disclosure Protocol is followed.

Official Statistics designation
Not Assessed

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Appendix 3 – Early Access Details

Pre-Release Access

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

Standard Pre-Release Access

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

Appendix 4 – NSS and Official Statistics

Official Statistics

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