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SWEDRES | SVARM

Sales of antibiotics and occurrence of antibiotic resistance in Sweden

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A report on Swedish Antibiotic Sales and Resistance in Human Medicine (Swedres) and Swedish Veterinary Antibiotic Resistance Monitoring (Svarm)

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Preface

The Swedres-Svarm report on the monitoring of antibiotic resistance and antibiotic sales in human and veterinary medicine has been produced jointly by the Swedish veterinary and public health sectors for more than two decades. Guided by a One Health mindset, data from humans, animals and food is collated and analysed in a comprehensive manner to allow for a comparative presentation of the current situation as well as trends over time. The report is a practical example of Sweden's ambition to show leadership in paving the way for interdisciplinary work to mitigate the effects of antibiotic resistance.

While this preface is being written, we are looking back at yet another year with recurring crises globally, with repercussions both nationally and internationally that hamper global cooperation, including in public and animal health. At the same time, the global community is preparing for the upcoming High-level meeting on antimicrobial resistance to be held in conjunction with the UN General Assembly in September, with discussions on how to accelerate political action on AMR based on the One Health approach.

This year's report shows that the sales of antibiotics for animal use is maintained at a low level. The trends with respect to resistance in important pathogens is similarly stable. However, this positive situation may be challenged in the near future. Constraints to the availability of antibiotics is an increasing challenge to both veterinary and human medical practice. As a consequence, veterinarians may find themselves having to choose products with a broader spectrum than desired, and in conflict with established best practice. This is of great concern with respect to the development of resistance and may also influence usage statistics.

On a positive note, access to new and old medical products, including antibiotics, is one of the focus areas of the recently updated National strategy for medical products 2024-2026. For the first time, the strategy includes a One Health perspective on this challenge - very timely and important as we need to ensure a robust and resilient supply of antimicrobials for people as well as animals.

Notably, from 2023 it is also compulsory to collect data on antibiotic use in farm animals within EU, which will give a better basis for strategic work regarding antibiotic resistance. As the deadline for reporting of use data to the European Medical Agency is in September 2024, the data analysis is still ongoing. It is therefore not included in this report.

In human medicine, antibiotic use has continued to increase without reaching prepandemic levels. Antibiotic resistance that is mandatory to report has increased as well. This is especially notable in Enterobacterales with $ESBL_{CARBA}$, which is at its highest number of cases, 314, since mandatory reporting started. This poses a threat to advanced healthcare and motivates continued and increased efforts to prevent the spread of antibiotic resistance and healthcare-associated infections. Still, Sweden continues to have one of the world's lowest levels of antibiotic resistance in humans and levels and increases are even higher in most other countries. This confirms that systematic and sustainable work on a national level is effective and that it is of foremost importance to sustain and further develop the work in order to uphold the access to effective antibiotics for humans globally and in Sweden. This includes working for better public health in general, leading to healthier people and less infectious disease, as well as traditional work against antibiotic resistance, such as antibiotic stewardship and infection prevention and control.

Important work started during the year, both in Europe and globally. The European Commission published recommendations to step up work against antibiotic resistance, including goals for antibiotic resistance levels and antibiotic use for the union and each member state. The World Health Organization has published a strategy for infection prevention and control, and now continues with an implementation plan with tools and a framework for monitoring progress. This is indeed good news for all who are dedicated to the work against the spread of antibiotic resistance.

Solna and Uppsala, June 2024

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Content

Sammanfattning/Summary

Sammanfattning

Under lång tid har Sverige haft en gynnsam situation jämfört med många andra länder när det gäller antibiotikaresistens hos bakterier från människor. Det läget kvarstår fortfarande. En av anledningarna är att vi har effektiva strategier för att främja en ansvarsfull användning av antibiotika och begränsa spridningen av antibiotikaresistens. Trots det goda läget finns det problem med kontinuerligt ökande antibiotikaresistens och smittspridning inom sjukvården. Viktiga exempel är de återkommande utbrotten av vankomycinresistenta enterokocker på sjukhus och ett ökande antal vårdrelaterade kluster av ESBL-CARBA. Detta poängterar vikten av ett kontinuerligt arbete inom Strama, vårdhygien och smittskydd för att förebygga infektioner och ökande antibiotikaresistens.

Antibiotikaförsäljningen inom humanmedicinen i Sverige minskade kraftigt under pandemin men började öka under 2022 och fortsatte att öka under 2023. Trots ökningen ligger försäljningen fortfarande under prepandemiska nivåer. Antibiotikaförsäljningen har minskat generellt sedan peaken i 1992. Störst minskning under denna period observerades hos barn i åldrarna 0–4 år.

Inom veterinärmedicinen har antibiotikaförsäljningen minskat kraftigt sedan mitten av åttiotalet för att de senare åren ha stabiliserats på en jämförelsevis låg nivå.

Vidare har förekomsten av resistens bland bakterier från djur generellt sett varit stabilt låg. För vissa substanser och bakterier har förekomsten över tid till och med minskat. Ett sådant exempel är ESBL-bildande Escherichia coli hos slaktkyckling. Det finns dock undantag, exempelvis har förekomsten av resistens mot ampicillin, sulfonamider och trimetoprim ökat hos slumpmässigt utvalda E. coli hos såväl slaktkyckling som slaktgris.

Viktiga fynd 2023

- Den totala antibiotikaförsäljningen inom humanmedicinen i Sverige ökade med 7,3 procent under 2023 jämfört med 2022. Det återspeglas inom både recept och rekvisitioner. Försäljningen av antibiotika inom tandvården minskade med 2,6 procent under samma period.
- Antibiotikaförsäljningen inom öppenvården ökade under året jämfört med året innan. Framför allt bidrog förskrivning av luftvägsantibiotika till barn till denna ökning.
- Sedan 2020 används resistens mot cefotaxim hos Escherichia coli och andelen meticillinresistenta Staphylococcus aureus (MRSA) isolerade från blod som indikatorer på antibiotikaresistens i Sverige. Både andelen MRSA och andelen E. coli som är resistenta mot cefotaxim har långsamt ökat under en tioårsperiod till nuvarande 2,1 respektive 7,6 procent. För båda indikatorerna har ökningen övergått i en platå under de senare åren.
- Under pandemin minskade antalet fall av flertalet typer av anmälningspliktig antibiotikaresistens. För de flesta av dessa ses nu tydliga ökningar, mest markant för ESBL-CARBA, där 314 fall rapporterades, mot 240 år 2022. Trettionio kluster eller parvis relaterade fall identifierades under 2023 (2-8 fall per kluster). För sexton av de 39 klustren, finns ett eller flera fall rapporterad som vårdrelaterad smitta i Sverige 2023.
- För vankomycinresistenta enterokocker förekom fem större (10-35 fall) och tolv mindre (2-6 fall) sjukhusrelaterade smittspridningar under 2023.
- Resistensnivåer bland kliniska isolat från människor påverkades inte av pandemin.
- Försäljningen av antibiotika för användning till djur är stabilt låg och domineras av penicillin med smalt spektrum.
- MRSA är ovanliga hos både lantbrukets djur och sällskapsdjur.
- ESBL-bildande E. coli är generellt sett ovanliga hos både lantbrukets djur och sällskapsdjur samt på kött.
- Bakterier som bildar ESBL-CARBA har inte bekräftats hos tamdjur i Sverige.

Försäljning av antibiotika

Antibiotikaförsäljning inom humanmedicin

Den totala mängden antibiotika som såldes i Sverige ökade med 7,3 procent under 2023 och ligger nu på 10,9 DDD per 1 000 invånare och dag. I detta innefattas all antibiotika som sålts på recept till individer och på rekvisition till olika vårdinrättningar och särskilda boenden.

Öppenvård

Antalet antibiotikarecept som hämtades ut på apotek under året låg på 270 recept per 1 000 invånare, en ökning med 7,5 procent jämfört med 2022. Bland landets 21 regioner uppnådde 4 regioner det nationella målet på högst 250 recept per 1 000 invånare. Försäljningen ökade i samtliga åldersgrupper, och den var högst i gruppen barn i åldern 5–14 år där den ökade med 51,9 procent jämfört med året innan. Tydligast var ökningen under det fjärde kvartalet. Denna ökning bestod framför allt av antibiotika som ofta används vid luftvägsinfektioner.

Försäljningen av antibiotika på recept inom tandvården minskade med 2,6 procent under 2023 jämfört med året innan, och utgör 7,2 procent av alla uthämtade antibiotikarecept under året. Sedan år 2007 har antibiotikaförsäljningen inom tandvården minskat med nästan hälften.

Sjukhus och andra vårdformer

Den totala försäljningen av antibiotika på rekvisition till vårdinrättningar ökade under 2023 med 5,7 procent jämfört med 2022. Försäljningen ökade i 20 av 21 regioner under samma period. Liksom tidigare år fanns stora regionala variationer i försäljningen av antibiotika på rekvistion.

Antibiotikaförsäljning inom veterinärmedicin

Försäljningen av antibiotika för djur från apotek i Sverige uppgick 2023 till 9 069 kilogram, varav 55 procent var penicillin med smalt spektrum. Försäljningen av antibiotika som bör

användas särskilt restriktivt (fluorokinoloner, tredje generationens cefalosporiner och polymyxin) har minskat väsentligt sedan 2013. Under samma tioårsperiod har andelen produkter för behandling av enstaka djur varit omkring eller över 90 procent av den totala försäljningen.

Den totala försäljningen av antibiotika för djur har minskat med över två tredjedelar sedan 1986, när användningen av tillväxtbefrämjande antibiotika upphörde. Detta är korrigerat för att antalet djur av olika arter har förändrats genom åren. Under 90-talet minskade användningen av antibiotika som läkemedel till hela djurgrupper, och under det senaste decenniet ses också en minskad användning av antibiotika för behandling av enstaka djur.

Jämförelse av försäljning inom human- och veterinärmedicin

Under 2023 såldes 64,4 ton antibiotika för behandling av människor och 8,9 ton för behandling av djur (inkluderar inte produkter för intramammärt eller intrauterint bruk). Uttryckt i relation till kroppsvikt (milligram aktiv substans per skattad kilogram biomassa) var försäljningen 91,2 milligram per kilogram för människor och 11,6 milligram per kilogram för djur.

Anmälningspliktig resistens

ESBL-bildande Enterobacterales

ESBL-bildande Enterobacterales hos människor har varit anmälningspliktigt sedan 2007. Det är den vanligaste av de anmälningspliktiga resistenstyperna.

Resultat 2023, Enterobacterales med ESBL

- Antal rapporterade fall: 10 895 (föregående år 9 611), relativ förändring: 13 procent ökning.
- Antal fall med blodförgiftning: 897 (föregående år 818).
- Som tidigare år var E. coli den vanligaste arten, 83 procent, följt av Klebsiella pneumoniae, 11 procent.
- Andelen E. coli från blododling som är resistenta mot tredje generationens cefalosporiner var 7,6 procent.

Resultat 2023, Enterobacterales med ESBL-CARBA

- Antal rapporterade fall: 314 (föregående år 240), relativ förändring: 31 procent ökning.
- Antal fall med blodförgiftning: 21 (föregående år 14).
- E. coli var den vanligaste arten, 61 procent, följt av K. pneumoniae, 28 procent.
- Antalet E. coli från blododling som är resistenta mot meropenem är 3 av 10 719, jämfört med 3 av 10 541 under 2022.
- Trettionio kluster, med mellan två och åtta fall vardera, har identifierats med helgenomsekvensering. Bland de 39 klustren ingår även 19 kluster som haft ett eller flera fall innan 2023. För sexton av de 39 klustren, finns ett eller flera fall rapporterad som vårdrelaterad smitta i Sverige 2023.

Bakterier som bildar ESBL är inte anmälningspliktiga vid fynd hos djur. Sådana bakterier är generellt sett ovanliga hos djur i Sverige. Tidigare var förekomsten hos slaktkyckling hög men den har minskat under senare år. Under 2023 undersöktes förekomsten av ESBL-bildande E. coli i tarmprov från slaktgris och slaktkyckling samt från köttprov från gris och nötkreatur med selektiva metoder.

Sådana bakterier hittades i 1 procent av tarmproven från slaktgris respektive slaktkyckling men inte i några av proven av griskött eller nötkött.

Bakterier som bildar ESBL-CARBA har inte bekräftats hos tamdjur i Sverige.

Staphylococcus aureus resistenta mot meticillin (MRSA)

Samhällsförvärvad smitta är sedan länge den vanligaste typen hos människor smittade med MRSA i Sverige, med hälften av fallen. Från 2015 rapporteras familje-/hushållssmitta och samhällsförvärvad smitta separat. Familje-/hushållssmitta och samhällsförvärvad smitta utgjorde 27 procent respektive 21 procent av fallen.

Resultat 2023

- Antal rapporterade fall: 3 547 (föregående år 3 340), relativ förändring: 6 procent ökning.
- Antal fall med blodförgiftning: 103 (föregående år 96).
- Andelen MRSA bland S. aureus från blododling har ökat till 2,1 procent, från 1,9 procent 2022.

Förekomsten av MRSA hos djur i Sverige är fortfarande låg, vilket begränsar risken för spridning till människor. Under året isolerades MRSA sporadiskt från djurslagen hund, häst och katt. Hos hundar och katter dominerar samma typer av MRSA som hos människor, vilket tyder på att människor är smittkällan. Hos hästar var antalet MRSA-fall 12 vilket är lägre än åren 2020–21 (27 respektive 23 fall), då det förekom utbrott av MRSA på hästsjukhus.

Staphylococcus pseudintermedius resistenta mot meticillin (MRSP)

Under 2023 var antalet anmälda fall av meticillinresistenta Staphylococcus pseudintermedius (MRSP) hos djur på ungefär samma nivå som de senaste åren. Totalt anmäldes 48 fall av MRSP till Jordbruksverket, varav 46 fall från hund samt två från katt. Samtliga isolat utom ett fanns tillgängliga för vidare undersökning. De första åren efter att MRSP hade hittats hos djur i Sverige var i princip alla fall av en viss sekvenstyp (ST71). På senare år förekommer fler olika sekvenstyper, (30 olika 2023) varav ST551 är den vanligaste.

MRSP är inte anmälningspliktig vid förekomst hos människor.

Streptococcus pneumoniae med nedsatt känslighet för penicillin (PNSP)

Resultat 2023

- Antal rapporterade fall: 152 (föregående år 146), relativ förändring: 4 procent ökning.
- Antal fall med blodförgiftning: 7 (föregående år 9).
- Andelen S. pneumoniae med nedsatt känslighet för penicillin (PNSP) från blododling har minskat till 5,8 procent, från 7,7procent 2022.

Enterococcus faecium och Enterococcus faecalis resistenta mot vankomycin (VRE)

Resultat 2023

- Totalt antal rapporterade fall: 260 (föregående år 236), relativ förändring: 10 procent ökning.
- Antalet fall av VRE kan variera kraftigt mellan år beroende på hur många och hur stora smittspridningar som förekommit på sjukhus.
- Antal rapporterade fall av E. faecium med vankomycinresistens: 250 (föregående år 227), relativ förändring: 10 procent ökning.
- Antal rapporterade fall av E. faecalis med vankomycinresistens: 10 (föregående år 4).
- Sex fall av VRE rapporterades med både E. faecium och E. faecalis.
- Antal fall med blodförgiftning: 5 (föregående år 5).
- Sjutton smittspridningar rapporterades under året med 2–35 fall. Av dessa var fem större sjukhusrelaterade utbrott med 10–35 fall vardera. År 2022 rapporterades sexton sjukhusrelaterade smittspridningar.
- Andelen VRE hos enterokocker från blododling är låg, 0,7 procent för E. faecium och 0,0 procent för E. faecalis.

Resistens hos zoonotiska bakterier

Salmonella är ovanligt hos djur i Sverige och isolerade stammar är oftast känsliga för antibiotika. Resistens mot fluorokinoloner är ovanlig. Bland 107 isolat från djur 2023 var 90 procent känsliga för alla testade antibiotika. För salmonellaarter var resistensen bland faeces isolat från människor högst mot fluorokinoloner, 24 procent. Ingen resistens mot karbapenemer rapporterades. Salmonella från invasiva infektioner hos människor är mer resistenta än isolat från djur i Sverige. Detta beror troligen på att en stor andel av fallen hos människor är smittade utomlands eller via importerade livsmedel.

Campylobacter från djur i Sverige är oftast känsliga för relevanta antibiotika och exempelvis är resistens mot erytromycin mycket ovanligt. Hos Campylobacter jejuni från människor var resistensen mot ciprofloxacin 56 procent och mot tetracyklin 26 procent 2023. Resistensen mot erytromycin var 1,9 procent.

Vanligtvis behandlas inte infektioner som orsakas av salmonella eller campylobacter med antibiotika, hos vare sig människor eller djur. Hos människor resistensbestäms därför endast en liten andel av isolaten, varav de flesta gäller allvarliga infektioner.

Resistens hos kliniska isolat från människor

Alla data för dessa sammanställningar samlas in automatiserat via Svebar, ett samarbete mellan de kliniska mikrobiologiska laboratorierna och Folkhälsomyndigheten.

- Escherichia coli: Resistens hos blodisolat mot ceftazidim och cefotaxim var 6,6 respektive 7,6 procent. Antalet anmälningar av E. coli ESBL från blod 2023 var 670. Resistens mot ciprofloxacin är nu 15 respektive 11 procent hos isolat från blod respektive urin, ett observandum vid val av empirisk behandling av febril urinvägsinfektion.
- Vid ålders- och könsfördelning av resultat för E. coli från urin ses vissa skillnader mellan grupperna. Speciellt tydligt är den höga ciprofloxacinresistensen (17–21 procent) hos män, 20 år och äldre.
- Klebsiella pneumoniae: Resistens hos blodisolat mot cefotaxim och ceftazidim var 9,6 respektive 8,6 procent. Antalet anmälningar av K. pneumoniae ESBL från blod 2023 var 144. Liksom för E. coli är resistensen mot ciprofloxacin nu relativt hög, 13 respektive 11 procent hos isolat från blod och urin.
- Staphylococcus aureus: Resistens mot cefoxitin (som indikerar MRSA) hos isolat från blod och prover från hud- och mjukdelar var 2,1 respektive 2,4 procent. Antalet anmälningar av MRSA från blod 2023 var 103.
- Enterococcus faecalis och Enterococcus faecium: Vankomycinresistensen hos isolat från blod är fortsatt låg (0,0 respektive 0,7 procent) och höggradig aminoglykosidresistens är fortfarande på en lägre nivå jämfört med 2017.
- Clostridioides difficile: Incidensen har legat relativt stabilt sedan 2018 och ligger nu på 60 fall per 100 000 invånare och år. Antibiotikaresistens har inte undersökts 2023.

Resistens hos kliniska isolat från djur

Bakterier som orsakar sjukdom hos djur är fortfarande oftast känsliga för de antibiotika som vanligen används. Till exempel är bakterier som orsakar luftvägsinfektioner hos lantbrukets djur och hästar generellt känsliga för bensylpenicillin men resistens förekommer exempelvis hos Pasteurella multocida från kalv. Penicillinresistens är däremot vanligt hos Staphylococcus pseudintermedius från hundar och förekommer hos S. aureus från hästar samt S. felis från katter, men är ovanligt hos S. schleiferi från hundar. Resistens hos E. coli från olika djurslag förekommer också och är vanligast hos isolat från träckprover från unga grisar. Resistensundersökning är motiverat för val av lämpligt antibiotikum vid behandling, särskilt för stafylokocker, E. coli och Brachyspira spp.

Indikatorbakterier från friska djur

Resistens hos E. coli i tarmfloran hos friska djur kan användas som indikator för utbredningen av antibiotikaresistens hos bakteriefloran i en djurpopulation och indirekt som indikator på omfattningen av antibiotikaanvändning till djuren. I Sverige är förekomsten av resistens hos dessa indikatorbakterier låg hos de flesta undersökta djurslagen och situationen är gynnsam ur ett internationellt perspektiv. Till exempel var 69 respektive 73 procent av E. coli från friska slaktkycklingar och slaktgrisar i de senast gjorda undersökningarna känsliga för alla testade substanser.

Summary

For a long time, Sweden has had a favourable situation compared to many other countries when it comes to antibiotic resistance in bacteria from humans, which remains true. One contributing factor is that we have effective strategies to promote the responsible use of antibiotics and limit the spread of antibiotic resistance. Despite the favourable situation, there are problems with continuously increasing antibiotic resistance and the spread of infections in healthcare. Important examples are the recurrent outbreaks of vancomycin-resistant enterococci in hospitals and an increasing number of healthcare-associated clusters of $ESBL_{CARBA}$. This emphasises the importance of continuous work with antibiotic stewardship and infection prevention and control, in healthcare as well as in the community to prevent increasing antibiotic resistance.

Antibiotic sales in human medicine in Sweden decreased sharply during the pandemic, but began to increase in 2022 and continued to increase in 2023. Despite the increase, sales remained below pre-pandemic levels. Antibiotic sales have generally decreased since the peak in 1992. The greatest decrease during this period was observed in children aged 0-4 years.

In veterinary medicine, sales of antibiotics have decreased markedly since the mid-1980s, and in recent years sales seem to have stabilised at a comparatively low level. The occurrence of resistance among bacteria from animals has generally been stable at low or moderate levels. For some substances and in some bacteria the occurrence of resistance is even declining. One example of this is a significant decline of the occurrence of ESBL-producing *Escherichia coli* among broilers. There are however exceptions, and for example resistance to ampicillin, sulphonamides and trimethoprim has increased in indicator *E. coli* from both broilers and pigs.

Key findings 2023

- Total sales of antibiotics for humans in Sweden increased by 7.3% in 2023 compared to 2022, as measured in DDD per 1 000 inhabitants per day. The increase was reflected in both outpatient and inpatient care. Antibiotic sales in dentistry decreased by 2.6% during the same period.
- Antibiotic sales in outpatient care increased during 2023 compared to 2022. Sales of antibiotics commonly used for respiratory tract infections in children especially contributed to this increase.
- Since 2020, resistance to cefotaxime in *Escherichia coli* and the proportion of methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from blood are used as indicators of antibiotic resistance in Sweden. Both the proportion of MRSA and the proportion of *E. coli* that are resistant to cefotaxime have slowly increased over a ten-year period to the current 2.1 and 7.6% respectively. For both indicators, the increase appears to have reached a plateau in recent years.
- During the pandemic, the number of cases of most types of notifiable antibiotic resistance decreased. For most of these, clear increases are now seen, most markedly for $ESBL_{CARBA}$, where 314 cases were reported, compared to 240 in 2022. Thirty-nine clusters, with between two and eight cases each, have been identified by whole-genome sequencing in 2023. For sixteen of the 39 clusters, there is one or more cases reported as healthcare-related infection in Sweden.
- Seventeen hospital-associated outbreaks of vancomycin-resistant enterococci were reported in 2023.
- Resistance levels among clinical isolates from humans were not affected by the pandemic.
- Sales of antibiotics for animals are stable at a low level and are dominated by narrow-spectrum penicillin.
- MRSA is uncommon among both farm and companion animals.
- ESBL-producing *E. coli* is generally uncommon among farm and companion animals as well as on meat.
- $ESBL_{CARBA}$-producing bacteria have not been confirmed in domestic animals in Sweden.

Sales of antibiotics

Sales of antibiotics for humans

The total sales of antibiotics for humans in Sweden increased by 7.3% in 2023 and was estimated at 10.9 DDD per 1 000 inhabitants per day. This figure encompasses all antibiotics sold on prescription to individuals and all antibiotics sold to hospitals and other health- and social care facilities.

Outpatient care

In 2023, 270 prescriptions per 1 000 inhabitants were dispensed at pharmacies in Sweden, an increase of 7.5% compared to 2022. Of the 21 regions in Sweden, four regions achieved the national long-term target of 250 or fewer prescriptions per 1 000 inhabitants and year. Antibiotic sales increased in all age groups with the highest increase in children aged 5-14 years, where sales increased by 51.9% compared to the year before. The most substantial increase occurred during the fourth quarter of 2023. This increase consisted primarily of antibiotics commonly used to treat respiratory tract infections.

The sales of antibiotics in dentistry decreased by 2.6% in 2023, and accounted for 7.2% of all outpatient antibiotic prescriptions during the year. Since 2007, the prescription of antibiotics by dentists has decreased by nearly half.

Hospitals and other health- and social care facilities

In 2023, the sales of antibiotics on requisition, including all antibiotics sold to hospitals and other health- and social care facilities, increased by 5.7% compared to 2022. Sales increased in 20 of 21 regions during the same period. As in previous years, there were large regional variations in the sale of antibiotics on requisition to the regions.

Sales of antibiotics for animals

In 2023, reported sales of antibiotics for animals from pharmacies in Sweden were 9 069 kg, of which around 55% were narrow-spectrum penicillins. Sales of antibiotics that should be used with special restrictions (fluoroquinolones, third generation cephalosporins and polymyxins) have decreased considerably since 2013. During the same decade,

the proportion of products for the treatment of individual animals has been around or over 90% of the total sales.

Since the withdrawal of growth-promoting antibiotics from the Swedish market in 1986, the total sales of antibiotics corrected for population sizes over time have decreased by more than two thirds. During the 1990s, sales of veterinary products for medication of groups of animals decreased, and in the past decade there has also been a decrease in sales of products for use in individual animals.

Comparing sales of antibiotics in human and veterinary medicine

In 2023, a total of 64.4 tonnes of antibiotics were sold for human use and 8.9 tonnes were sold for animal use (excluding products for intramammary or intrauterine use). Measured as milligrams of active substance per kilogram biomass, the corresponding sales were 91.2 and 11.6 milligrams per kilogram, respectively.

Notifiable resistance

ESBL-producing Enterobacterales

ESBL-producing Enterobacterales in humans has been subject to mandatory notification since 2007. It is the most common type of notifiable antibiotic resistance.

Results 2023, Enterobacterales with ESBL

- Number of reported cases: 10 895 (previous year 9 611), relative change +13%.
- Number of bloodstream infections: 897 (previous year 818).
- As in previous years, *Escherichia coli* was the most common species, (83%), followed by *Klebsiella pneumoniae*, (11%).
- The proportion of *E. coli* from blood cultures that are resistant to third-generation cephalosporins were 7.6% as in 2023.

Results 2023, Enterobacterales with $ESBL_{CARBA}$

- Number of reported cases: 314 (previous year 240), relative change +31%.
- Number of bloodstream infections: 21(previous year 14).
- Among Enterobacterales with $ESBL_{CARBA}$, *E. coli* was the most common species, (61%) followed by *Klebsiella pneumoniae* (28%).
- Thirty-nine clusters or pairwise linked cases of $ESBL_{CARBA}$ were identified by whole-genome sequencing in 2023 (2-8 cases per cluster). Of the 39 clusters, 19 clusters had at least one case prior to 2023. For 16 of the 39 clusters, there is one or more cases reported as healthcare-related infection in Sweden.
- The number of *E. coli* from blood cultures resistant to meropenem was 3 out of 10 719, compared to 3 out of 10 541 in 2022.

ESBL-producing Enterobacterales are generally rare among animals in Sweden. Previously, the occurrence in intestinal samples from broilers was high but it has decreased in recent years. In 2023, the occurrence of ESBL-producing *E. coli* in intestinal samples from fattening pigs and broilers, as well as samples of pig and cattle meat was investigated with selective methods. Such bacteria were isolated from 1% of the intestinal samples from pigs and broilers, respectively but such bacteria were not isolated from any of samples of pig meat or cattle meat.

Bacteria that produce $ESBL_{CARBA}$ have not been confirmed in domestic animals in Sweden.

Methicillin-resistant Staphylococcus aureus (MRSA)

Community-acquired infection has long been the most common type in humans, accounting for half of the cases. In 2015, community-acquired infection was divided into family/household-related infection and community-acquired infection. Family/house-hold-related infections and community-acquired infections accounted for 27% and 21% of the cases, respectively.

Results 2023

- Number of reported cases: 3 547 (previous year 3 340), relative change +6%.
- Number of bloodstream infections: 103 (previous year 96).
- The proportion of MRSA among *Staphylococcus aureus* isolated from blood has Increased to 2.1%, compared to 1.9% in 2022.

The occurrence of MRSA in animals in Sweden is still low, which limits the spread from animals to humans. MRSA was found sporadically in horses, dogs, and cats. The increase of MRSA cases, compared to previous years, seen in horses in 2020 and 2021 was partly explained by outbreaks in equine hospitals. In 2023 there were 12 cases, and no outbreaks. In companion animals, the same types of MRSA as in humans dominate, indicating a human source of MRSA in these animals.

Methicillin-resistant Staphylococcus pseudintermedius (MRSP)

In 2023, the number of reported cases of methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) in animals was around the same level as in previous years. In total 46 cases of MRSP were notified to the Swedish Board of Agriculture, including 44 from dogs and two from cats. All but one isolates were available for further investigations. When MRSP first occurred among animals in Sweden, the sequence type ST71 dominated. However, for several years the isolates of MRSP have been more diverse with several sequence types occurring.

MRSP in humans is not notifiable.

Streptococcus pneumoniae with reduced susceptibility to penicillin (PNSP)

Results 2023

- Number of reported cases: 152 (previous year 146), relative change +4%.
- Number of bloodstream infections: 7 (previous year 9).
- The proportion of *S. pneumoniae* with reduced susceptibility to penicillin (PNSP) among bloodstream infections decreased to 5.8% from 7.7% 2022.

Vancomycin-resistant enterococci (VRE)

Results 2023

- Total number of reported cases: 260 (previous year: 236), relative change +10%.
- The number of cases of VRE can vary greatly between years depending on the number and magnitude of hospital outbreaks.
- Number of reported cases of *E. faecium* with vancomycin resistance: 250 (previous year: 227), relative change +10%
- Number of reported cases of *E. faecalis* with vancomycin resistance: 10 (previous year: 4)
- There were six cases infected with both *E. faecium* and *E. faecalis*.
- Number of bloodstream infections: 5 (previous year: 5)
- Seventeen clusters were reported during the year with 2-35 cases each. Out of these, five were large hospital-related outbreaks with 10-35 cases each. In 2022, sixteen hospital-related outbreaks were reported.
- The proportion of VRE among bloodstream infections is low at, 0.7% for *E. faecium* resistant to vancomycin and 0.0% for *E. faecalis* resistant to vancomycin.

Zoonotic pathogens

Salmonella is rare in animals in Sweden. Furthermore, only a few of the notified cases involve antibiotic resistant strains. Resistance to fluoroquinolones is rare. Among 107 isolates from animals in 2023, 90% were susceptible to all antibiotics tested.

For *Salmonella* species isolated from human faeces, the highest occurrence of resistance was to fluoroquinolones, (24%). No resistance to carbapenems was reported. Isolates from human invasive infections with *Salmonella* are markedly more resistant, probably due to the large proportion of cases acquired abroad.

Campylobacter from animals in Sweden are generally susceptible to relevant antibiotics, and resistance to erythromycin, for example, is most uncommon. In *Campylobacter jejuni* from humans, resistance to ciprofloxacin was 56% and resistance to tetracycline was 26% in 2022, and 1.9% of the isolates were resistant to erythromycin.

Infections, either in humans or i in animals, caused by *Salmonella* and *Campylobacter* are usually not treated with antibiotics. In humans, only a small proportion of the isolates, most of which are related to serious infections, are tested for antibiotic susceptibility.

Human clinical isolates

All data for these compilations are collected automatically via Svebar, a collaboration between the clinical microbiology laboratories and the Public Health Agency.

Escherichia coli: Resistance in blood isolates to ceftazidime and cefotaxime was 6.6 and 7.6% respectively. The number of reported *E. coli* ESBL from blood was 670 cases in 2023. Resistance to ciprofloxacin is now 15% and 11%, respectively, in isolates from blood and urine. This needs to be considered when choosing empirical treatment for febrile urinary tract infection.

When *E. coli* from urine are divided by age and gender, some differences in resistance are seen. Most prominent is the high ciprofloxacin resistance (17-21%) seen among men 20 years and older.

Klebsiella pneumoniae: resistance in blood isolates to cefotaxime and ceftazidime was 9.6 and 8.6% respectively. The number of reported *K. pneumoniae* ESBL from blood was 144 cases in 2023. As for *E. coli*, resistance to ciprofloxacin is now relatively high at, 11-13% in isolates from urine and blood.

Staphylococcus aureus: Resistance to cefoxitin (which is indicative of MRSA) in isolates from blood and samples from skin and soft tissue was 2.1% and 2.4% respectively. The number of reported MRSA from blood was 103 cases in 2023.

Enterococcus faecalis and *Enterococcus faecium*: Vancomycin resistance in isolates from blood remains low (0.0% and 0.7%, respectively) and high-level aminoglycoside resistance is still on a lower level compared to 2017.

Clostridioides difficile: The incidence has been relatively stable since 2018 and was now 60 cases per 100 000 inhabitants and year. No isolates were tested for antibiotic resistance in 2023.

Animal clinical isolates

Bacteria causing clinical disease in animals are mostly susceptible to antibiotics relevant for treatment. Respiratory pathogens from farm animals and horses are generally susceptible to benzylpenicillin, but resistance occurs, for example in *Pasteurella multocida* from calves. Penicillin resistance is common in *Staphylococcus pseudintermedius* from dogs and occurs in *S. aureus* from horses and *S. felis* from cats. However, in *S. schleiferi* from dogs penicillin resistance is uncommon. Resistance to commonly used antibiotics in *E. coli* occurs in all animals but is most prominent in enteric isolates from young pigs. Susceptibility testing for guidance in antibiotic therapy is warranted, especially for staphylococci, *E. coli*, and *Brachyspira* spp.

Indicator bacteria from healthy animals

Antibiotic resistance in *E. coli* from the intestinal flora of healthy animals serves as an indicator of the presence of resistance in an animal population. The prevalence of acquired resistance in such commensal bacteria also indirectly indicates the magnitude of the selective pressure from the use of antibiotics in an animal population. The prevalence of resistance in indicator bacteria from animals in Sweden is low, and the situation is favourable in an international perspective. As an example, in the latest investigations of indicator *E. coli* from broilers and pigs, 69% and 73% respectively, were susceptible to all tested substances.

Guidance for readers

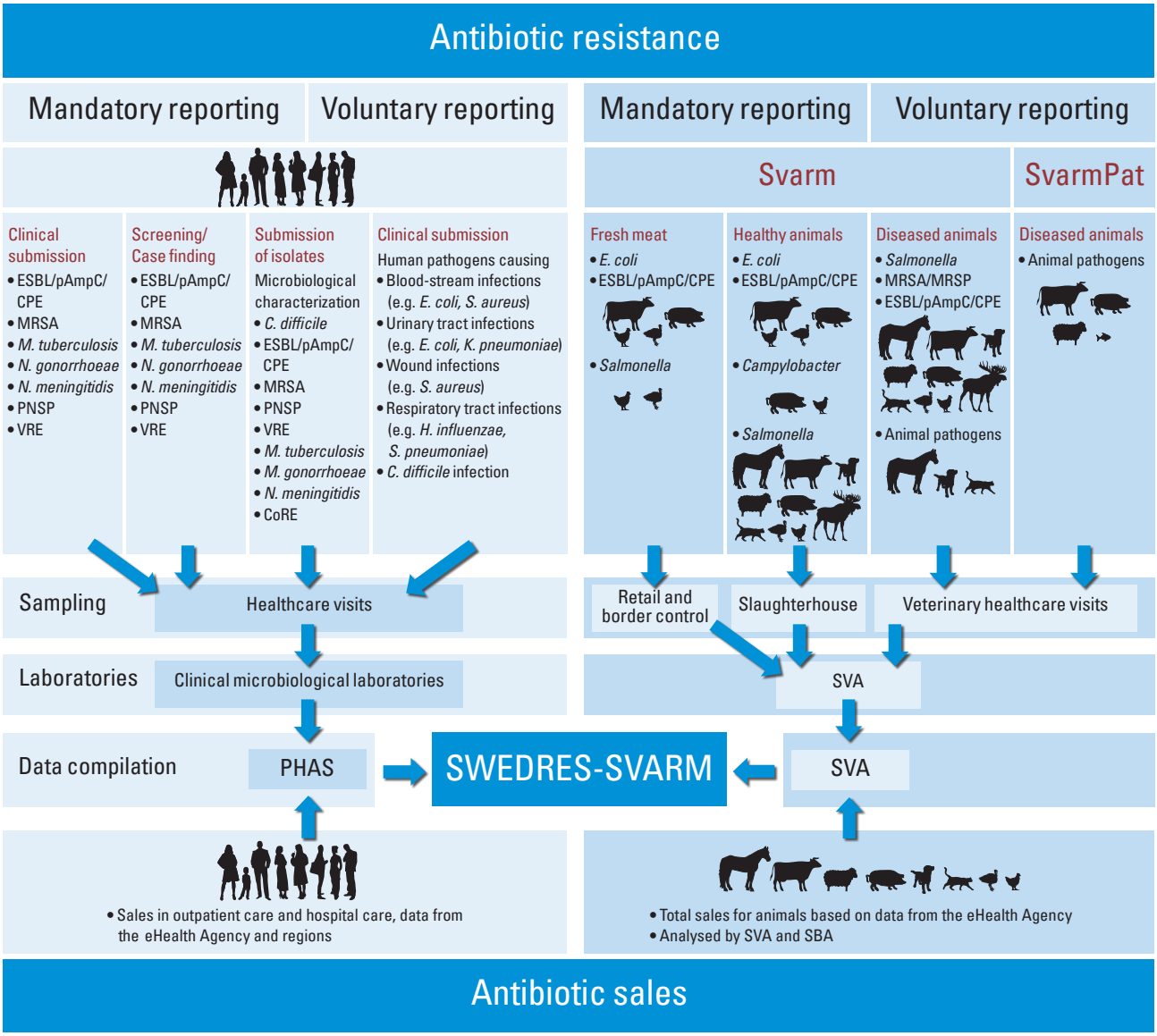
The Swedres-Svarm report is the result of a cooperation between the Public Health Agency of Sweden and the Swedish Veterinary Agency with the aim to present data relating to both humans and animals on the sales of antibiotics and on antibiotic resistance in a joint report.

Data on occurrence of notifiable antibiotic resistance in bacteria as well as data on resistance in zoonotic bacteria and in bacteria from clinical submissions are presented. Additionally, the report includes data on sales of antibiotics and resistance in so called indicator bacteria from healthy animals and from food of animal origin.

Data on resistance in bacteria from humans are mainly obtained from clinical microbiology laboratories and in addition via notifications from clinicians. They are compiled by the Public Health Agency of Sweden in Swedres. In contrast, data on animals and food, compiled by the Swedish Veterinary Agency, are from the national monitoring program in the veterinary field Svarm. This program is specifically designed to monitor resistance in bacteria from animals and food and is organised and run at the Swedish Veterinary Agency. Data in the veterinary field also emanate from other sources, such as the SvarmPat project and specific research projects. For details on data sources see respective bacteria in Antibiotic resistance in animals and Background data, material, methods and references.

Schematic view of antimicrobial sales and resistance monitored in Sweden 2023.

Resistance in bacteria from humans and sales for humans to the left and resistance in bacteria from animals and food and sales for animals to the right.



Embedded files in the PDF-file version of the report

The data from many of the tables and figures in Swedres-Svarm can be accessed from embedded Excel-files. To access the embedded files, indicated with paperclips, we recommend using Adobe Acrobat Reader.

Antibiotic sales

Swedres - Humans

Antibacterials for systemic use in humans are indexed as J01 in the Anatomical Therapeutic Chemical classification system. The J01 group also includes the antiseptic substance methenamine, which is not an antibiotic and is not a driver of antibiotic resistance. Throughout this report, methenamine is excluded whenever antibiotics are referred to or presented as a group. Statistics for dentistry includes oral metronidazole (P01AB01) in addition to antibiotics in the J01 group.

All pharmacies in Sweden are required to provide statistics on sales of all products on a regular basis to the Swedish eHealth Agency (eHälsomyndigheten), which maintains a national database with sales statistics for all drugs. The database includes statistics on prescriptions to individuals issued by healthcare providers from all 21 regions in Sweden and encompasses primary healthcare centres, outpatient specialist clinics, hospitals and dental clinics. In addition, statistics on medicines sold on requisition to hospitals, nursing homes and other health- and social care facilities are also accessible through the database. While prescription data accurately reflects antibiotic use, procurement data based on requisitions are impacted by procurement-related factors that may over- or underestimate antibiotic use. For detailed description of the pharmaceutical system in Sweden, please refer to the *Materials and methods, sales of antibiotics* section.

Comparison of sales of antibiotics between regions and to the elderly population over time is complicated by the fact that there are differences in how drugs are distributed to residents in nursing homes. In Sweden, most people living in nursing homes still receive their medication by prescription, whereby data are included in outpatient sales. However, there are also nursing homes where medicines are procured by the facility and then dispensed to the residents. These sales are included in inpatient care data. Since routines differ between regions and over time, the estimation of antibiotic use to the elderly population is not entirely reliable.

Wherever sales of antibiotics to a certain population group are displayed (children aged 0-6 years, women aged 15-79 years, inhabitants in a region), the denominator is the total number of individuals in the same population group.

In this report the term 'outpatient care' includes all antibiotic sales on prescription to individuals. 'Inpatient care' includes antibiotic sales to hospitals, nursing homes and other health- and social care facilities. Since national data on antibiotic sales to hospitals in Sweden are combined with sales to some nursing homes and other facilities, the figures are not suitable for evaluation of antibiotic use in acute care hospitals.

As data on antibiotic sales to humans are not linked to treatment indications, this report has grouped antibiotics frequently prescribed for treatment of common infections in Sweden in order to estimate the prescription rates for these diagnoses. All figures and tables referring to these treatment indications are based on the following antibiotics:

Oral antibiotics commonly prescribed for specific therapeutic areas in Sweden

Indication	Antibiotics included
Respiratory tract infections (RTIs)	Doxycycline (J01AA02; excluding packages larger than 50 tablets), penicillin V (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE; excluding ceftibuten J01DD14) and macrolides (J01FA).
Urinary tract infections (UTIs)	Pivmecillinam (J01CA08), trimethoprim (J01EA01), ciprofloxacin (J01MA02), norfloxacin (J01MA06) until 2020 and nitrofurantoin (J01XE01).
Skin and soft tissue infections (SSTIs)	Clindamycin (J01FF01) and flucloxacillin (J01CF05).
Acne vulgaris	Doxycycline (J01AA02; packages over 50 tablets), lymecycline (J01AA04), oxytetracycline (J01AA06) and tetracycline (J01AA07).

Antibiotic resistance

Swedres - Humans

Most of the data on resistance in Swedres is derived from routine diagnostic samples sent for testing at clinical microbiological laboratories. The results are mostly presented as proportion of resistance in tables or graphs. The methods used for antibiotic susceptibility testing, whether MIC determination or disk diffusion method, are standardised by European Committee on Antimicrobial Susceptibility Testing (EUCAST) and available online at www.eucast.org. The methods and breakpoints routinely used in Sweden are available at www.nordicast.org. EUCAST also presents yearly updated interpretative criteria for clinical use in human medicine, i.e. clinical breakpoints, also available at www.eucast.org.

Svarm - Animals and food

Data on resistance in Svarm are from MIC determinations performed at the Swedish Veterinary Agency using broth microdilution following the standards of the Clinical and Laboratory Standards Institute (CLSI, 2024a). Results for isolates of zoonotic and indicator bacteria are interpreted according to ECOFFs from EUCAST (www.eucast.org). Clinical isolates from animals are generally classified by ECOFFs when such values are available. Interpretive criteria used are given in the section Materials and methods resistance in bacteria from animals.

ECOFFs classify isolates with acquired reduced susceptibility as non-wild type. In Svarm, non-wild type isolates are called “resistant”. This classification is relevant for monitoring purposes, but it should be understood that resistance defined in this manner not always implies clinical resistance.

Since the first report from Svarm, the interpretive criteria for some combinations of bacteria and substance have been changed. To facilitate comparisons when retrospect data are presented, levels of resistance have been recalculated using current interpretive criteria if not otherwise stated.

Indicator bacteria in animals

In Svarm, *Escherichia coli*, and sometimes *Enterococcus faecalis* and *E. faecium* serve as indicators for presence of antibiotic resistance in the enteric flora of healthy animals and in the flora contaminating food. The prevalence of acquired resistance in such commensal bacteria in animals indicates the magnitude of the selective pressure from use of antibiotics in an animal population. Most bacteria of the enteric flora are unlikely to cause disease, but they can be reservoirs for resistance genes that can spread to bacteria that cause infections in animals or humans. Prevalence of resistance in indicator bacteria contaminating meat indicates the magnitude of the potential human exposure to such reservoirs in food producing animals.

Presentation of MIC distributions in bacteria from animals

Results from MIC determinations in Svarm are presented as distributions of MICs in tables of a uniform design as below. Distributions are given as percentages of isolates tested. In the tables, white fields denote range of dilutions tested for each antibiotic and vertical bold lines indicate cut-off values used to define resistance.

The percentage of isolates with a certain MIC of an antibiotic is given in the corresponding white field. For MICs above the range tested of an antibiotic (>X mg/L) the percentage is given in the field closest to the range, i.e. in the first shaded field to the right of the tested range. For MICs equal to or lower than the lowest concentration tested for an antibiotic (≤Y mg/L) the percentage is given as the lowest tested concentration, i.e. in the first white field of the tested range.

Multidrug resistance

The terms multidrug resistance (MDR), multiresistance and multiresistant are in Svarm generally used for isolates with acquired resistance to three or more antibiotic classes. However, for aminoglycosides every substance is considered separately because of the complexity of the resistance mechanisms against this class. Furthermore, for staphylococci each subclass of beta-lactams is considered separately but for Enterobacterales all beta-lactams are considered as one class.

Presentation of MIC distributions in bacteria from animals

Antibiotic	Resistance (%)	Distribution (%) of MICs (mg/L)											
		≤ 0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ciprofloxacin	21	21.0	52.0	6.0			1.0			20.0			
Erythromycin	0				93.0	4.0	3.0						
Tetracycline	2		75.0	22.0	1.0			1.0	1.0				

Abbreviations of generic antibiotic names

When abbreviations for antibiotics were needed in tables or graphs the following were used.

Amp	Ampicillin	Ery	Erythromycin	Nit	Nitrofurantoin
Azt	Azithromycin	Flf	Florfenicol	Oxa	Oxacillin
Bac	Bacitracin	Fox	Cefoxitin	Pen	Penicillin G
Caz	Ceftazidime	Fus	Fusidic acid	Ptz	Piperacillin-Tazobactam
Cdr	Cefadroxil	Gen	Gentamicin	Rif	Rifampicin
Cer	Ceftiofur	Imp	Imipenem	Str	Streptomycin
Cet	Cephalothin	Kan	Kanamycin	Sul	Sulphonamide
Chl	Chloramphenicol	Lin	Linezolid	Tet	Tetracycline
Cip	Ciprofloxacin	Mec	Mecillinam	Tgc	Tigecycline
Cli	Clindamycin	Mer	Meropenem	Tmp	Trimethoprim
Col	Colistin	Nal	Nalidixic acid	Tsu	Trimethoprim-sulphonamide
Ctx	Cefotaxime	Nar	Narasin	Tob	Tobramycin
Enr	Enrofloxacin	Neo	Neomycin	Van	Vancomycin

Abbreviations

AST	Antimicrobial susceptibility testing
ATC	Anatomical Therapeutic Chemical classification system
BSI	Bloodstream infection
CDI	*Clostridioides difficile* infection
CSF	Cerebrospinal fluid
DDD	Defined daily dose
ECDC	European Centre for Disease Prevention and Control
ECOFF	Epidemiological cut-off value for non-susceptibility
EARS-Net	European antimicrobial resistance surveillance network
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
EMA	The European Medicines Agency
ESC	Extended spectrum cephalosporin
ESBL	Extended spectrum beta-lactamase
$ESBL_A$	Extended spectrum beta-lactamase, plasmid-mediated, inhibited by clavulanic acid (A = classical)
$ESBL_M$	Extended spectrum beta-lactamase inhibited by cloxacillin, also called plasmid-mediated AmpC (M = miscellaneous)
$ESBL_{CARBA}$	Extended spectrum beta-lactamase with activity against carbapenems
EUCAST	European Committee on Antimicrobial Susceptibility Testing
GBS	*Streptococcus agalactiae* (Group B streptococci)
GLASS	Global Antimicrobial Resistance and Use Surveillance System
HLAR	High-level aminoglycoside resistance (e.g. in *Enterococcus*)
MALDI-TOF MS	Matrix-assisted-laser-desorption/ionization time-of-flight mass spectrometry
MDR	Multidrug resistance, i.e. phenotypic resistance to three or more antibiotic classes
MIC	Minimal inhibitory concentration
MLST	Multilocus sequence typing
MRSA	Methicillin-resistant *Staphylococcus aureus*
MRSP	Methicillin-resistant *Staphylococcus pseudintermedius*
NordicAST	Nordic Committee on Antimicrobial Susceptibility Testing
PHAS	Public Health Agency of Sweden
PNSP	*Streptococcus pneumoniae* with reduced susceptibillity to penicillin
PVL	Panton-Valentine leukocidin
ResNet	Webb application for Resistance surveillance and quality control programme
RSV	Respiratory syncytial virus
RTI	Respiratory tract infection
spa	*Staphylococcus aureus* protein A gene
SSTI	Skin and soft tissue infection
ST	Sequence type
Strama	Swedish strategic programme against antibiotic resistance
SVA	Statens veterinärmedicinska anstalt (Swedish Veterinary Agency)
TB	Tuberculosis
UTI	Urinary tract infection
VRE	Vancomycin-resistant enterococci
XDR	Extreme drug resistance (used for *Mycobacterium tuberculosis*)

Sales of antibiotics for humans

Exceptional changes to antibiotic sales in Sweden were observed during 2020 and 2021 due to the COVID-19 pandemic. Recommendations issued to reduce the spread of COVID-19 resulted in changed behaviour in the general population, which in turn led to a reduced spread of communicable diseases in general. Healthcare-seeking behaviour appears to have been affected, and the management of the COVID-19-pandemic forced health care to reprioritise resources, leading to, for example, cancelling or postponing some planned healthcare visits and elective surgeries (National Board of Health and Welfare, 2021). These factors affected the sales of antibiotics during this period. Most notably, considerable decreases were observed in prescriptions to children, especially of antibiotics commonly used to treat respiratory tract infections.

Total sales of antibiotics have continued to increase during 2023, while remaining lower than before the pandemic. This increase was most notable for antibiotics commonly prescribed for respiratory tract infections in children, reaching higher sales levels than those seen in 2019. The same factors that contributed to a decline in antibiotic sales during the first years of the pandemic likely explain this increase. More social interactions contributed to the increased spread of communicable diseases, as evidenced by surveillance data on common viral and bacterial infections; surges in infections with respiratory syncytial virus (RSV), influenza virus, COVID-19 and a particular increased incidence in group A streptococci were reported during 2023. During 2023, infections with invasive group A streptococci reached the highest reported incidence since reporting became mandatory in 2004 (Public Health Agency, 2024a-d). Additionally, regular seasonal variations of viral infections have been disrupted, leading to a large burden of several respiratory infections towards the end of the 2022 that likely continued into the beginning of 2023 (Public Health Agency, 2024a-c).

An increase in antibiotic prescribing following the removal of COVID-19 restrictions was expected and antibiotic prescribing was closer to pre-pandemic levels in 2023 than 2022. The increase in antibiotic prescribing observed in outpatient care during 2023 was in line with the increase in number of respiratory infections. Continued antimicrobial stewardship efforts are needed to ensure that appropriate prescribing practices are maintained, especially as primary care contacts have increasingly shifted from physical visits towards digital appointments (Cederberg, 2021).

The data sources and methodology underlying the statistics presented in this chapter are described in the *Materials and methods*, *sales of antibiotics* section. Due to regulations regarding the confidentiality of sales data, detailed data for substances and substance groups cannot be shown measured in DDD per 1 000 inhabitants. This affects the section for total sales as well as inpatient care.

Total sales of antibiotics

Results

- Total sales of antibiotics (J01 excl. methenamine) increased by 7.3% compared to 2022 (from 10.2 DDD to 10.9 DDD per 1 000 inhabitants per day), Figure 1.1.
- Total sales of antibiotics varied between regions, ranging from 9.5 DDD per 1 000 inhabitants per day in Jönköping region to 12.2 DDD per 1 000 inhabitants per day in Gotland region, Figure 1.1.
- Beta-lactamase sensitive penicillins (J01CE) and tetracyclines (J01AA) remain the two most sold antibiotic classes measured in DDD per 1 000 inhabitants in Sweden during 2023 (data not shown). The sales in outpatient care and inpatient care constitute 85.1% and 14.9% of the total sales, respectively.

Comments

Nationally, the sales of antibiotics increased in 2023 but remained below the sales volumes observed in 2019, before the COVID-19 pandemic. Regionally, antibiotic sales volumes in 2023 were higher in nine of 21 regions compared to sales volumes observed in 2019. A comparison with the population-weighted mean of the EU/EEA countries from 2012-2022 (ECDC, 2023) confirms Sweden's restrictive position regarding antibiotic prescribing. Due to regulations regarding the confidentiality of sales data, detailed data for substance groups cannot be shown.

Antibiotics in outpatient care

Total sales in outpatient care

Results

- In 2023, 270 prescriptions per 1000 inhabitants were sold in Sweden – an increase of 7.5% compared to 2022.
- Sales of antibiotics increased for all age groups in 2023, with the largest increase observed for children aged 5-14 years (51.9% increase compared to 2022, Figure 1.2). Compared to 2019, all groups showed a decrease in sales except for those aged 5-14, with an increase of 7.8%.
- An increase in sales was observed for most antibiotic classes in 2023, but a decrease was observed for amoxicillin (J01CA04), combinations of penicillins (J01CR) and fluoroquinolones (J01MA), Figure 1.3. Sales in the group other antibacterials (J01XX) consisted mainly of methenamine (J01XX05).
- Beta-lactamase sensitive penicillins (J01CE) and beta-lactamase resistant penicillins (J01CF) were the most commonly sold antibiotics in 2023 measured in number of prescriptions.
- The number of prescriptions per 1 000 inhabitants varied between 222 in Västerbotten region to 303 in Skåne region in 2023. Antibiotic sales increased in all 21 regions during 2023, Figure 1.4.
- In 2023, 15.8% of the Swedish population was treated with at least one course of antibiotics, ranging from 17.3% in Skåne region to 12.5% in Västerbotten region, Figure 1.5.

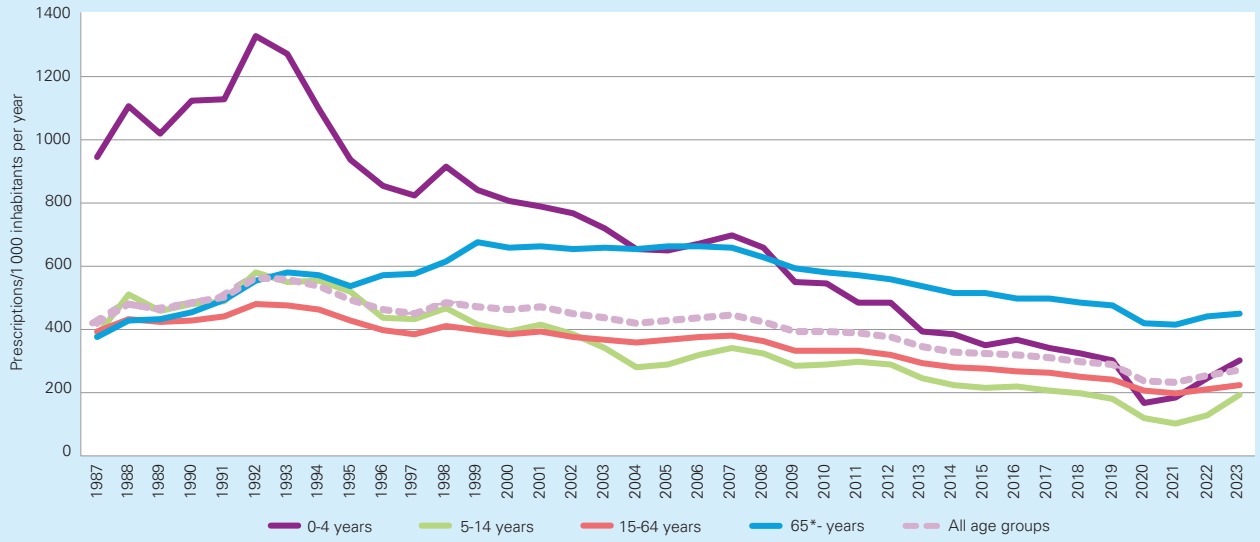
Figure 1.1. Total sales of antibiotics (J01 excl. methenamine) in 2019-2023, by region.

Source: The Public Health Agency of Sweden

Comments

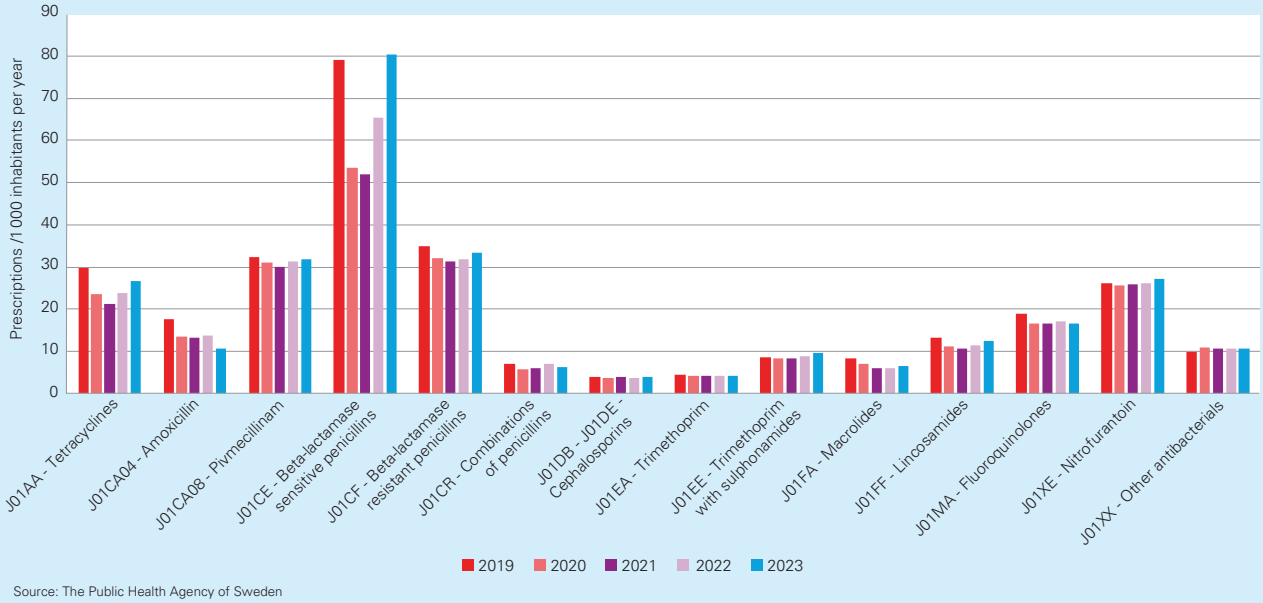
The sales of antibiotics have decreased by 51.8% since 1992, when the prescription of antibiotics peaked. The greatest decrease during this period was observed in children aged 0-4 years, dropping from 1 328 prescriptions per 1 000 inhabitants in 1992 to 299 in 2023, a decrease of 77.5%. In 2018, the national annual average sales of antibiotics were below 300 prescriptions per 1 000 inhabitants for the first time since national monitoring started. The COVID-19 pandemic led to a steep decrease in sales of antibiotics in 2020 and 2021, which was most noticeable for children aged 0-4 years. In 2020 and 2021 the national long-term target of 250 prescriptions per 1 000 inhabitants per year was achieved nationally (Strama, 2016). The national annual average of sales has returned to above the target of 250 prescriptions per 1 000 inhabitants following the pandemic. Four of 21 regions reached this annual target in 2023. This indicates that this temporary national achievement was a consequence of the COVID-19 pandemic and emphasises the continued need for antibiotic stewardship efforts. The decrease in sales for fluoroquinolones (J01MA) observed in 2023 compared to both 2022 and 2019 is in line with recommendations for restrictive use due to known risks of side effects (EMA, 2019).

Figure 1.2. Sales of antibiotics (J01 excl. methenamine) in outpatient care by age group in 1987-2023.



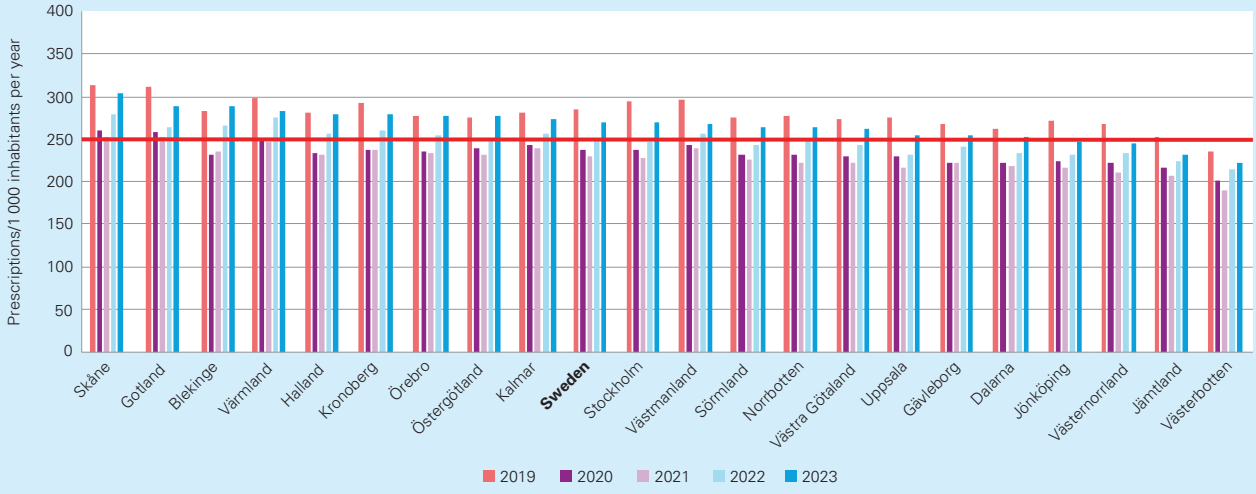
Source: The Public Health Agency of Sweden

Figure 1.3. Sales of selected antibiotic classes (ATC level 4 and 5) in outpatient care between 2019 and 2023.



Source: The Public Health Agency of Sweden

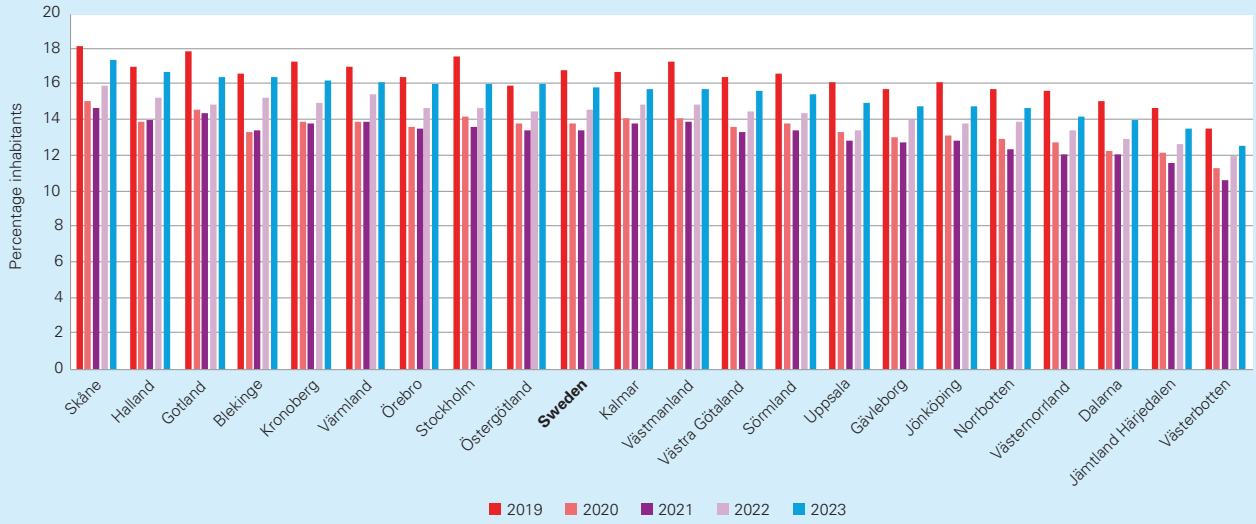
Figure 1.4. Sales of antibiotics (J01 excl. methenamine) in outpatient care in 2019-2023, by region[a].



[a]The red line indicates the national target of 250 prescriptions or less per 1 000 inhabitants per year.

Source: The Public Health Agency of Sweden

Figure 1.5. Percentage (%) of inhabitants treated with at least one course of antibiotics (J01 excl. methenamine) in outpatient care from 2019 to 2023, by region.



Source: The Public Health Agency of Sweden

Antibiotics commonly used to treat certain infections in outpatient care

Results

- The sales of antibiotics commonly used to treat respiratory tract infections (RTIs) were higher in the first quarter of 2023 compared to the same period in 2022. The sales peaked in December 2023, similarly to sales in December 2022. Sales of antibiotics commonly used to treat urinary tract infections (UTIs), skin and soft tissue infections (SSTIs) and acne remained relatively stable and followed the expected periodic fluctuations, Figure 1.6.
- Overall sales of antibiotics commonly prescribed against RTIs increased by 13.2% in 2023 compared to 2022.
- The number of prescriptions per 1 000 inhabitants for RTIs varied between 149 in Skåne region to 83 in Västerbotten region in 2023, Figure 1.7.

Comments

The effect of the decrease in sales due to the COVID-19 pandemic, primarily observed for antibiotics commonly used to treat RTIs and to a smaller degree UTIs, diminished during 2023. While sales for antibiotics commonly used to treat RTIs increased during 2023, the sales levels remain under pre-pandemic levels. The pandemic had a small or negligible effect on antibiotics sales commonly used for SSTIs and acne. For all regions, the majority of antibiotic prescriptions during 2023 were for antibiotics commonly used to treat

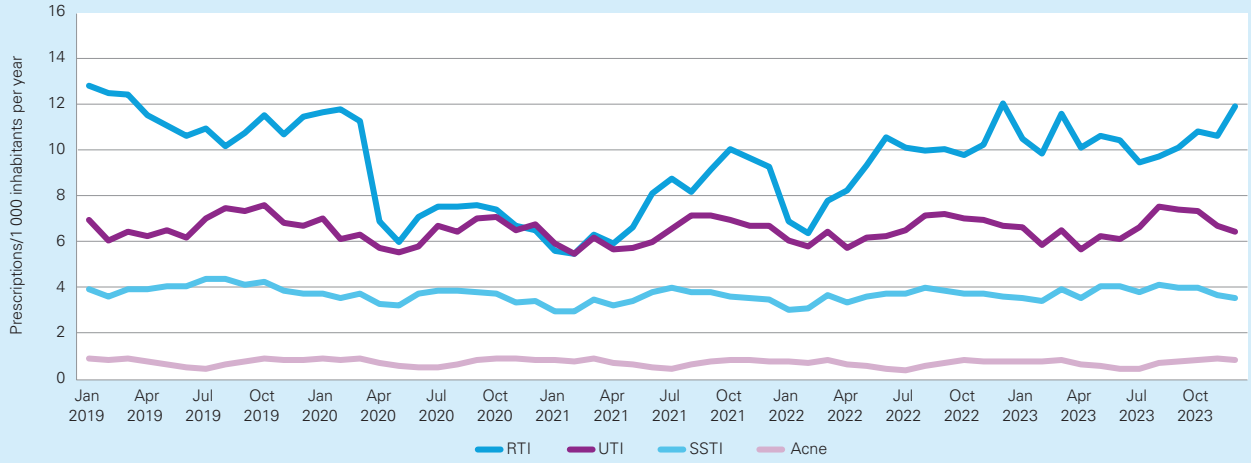
RTIs. In line with observations of antibiotic sales over many years, antibiotics commonly used to treat RTIs show larger regional variations than the remaining groups.

Respiratory tract infections (RTIs)

Results

- Beta-lactamase sensitive penicillins (J01CE02) were the most frequently prescribed of antibiotics commonly prescribed for RTIs in outpatient care in 2023, and increased by 22,7% compared to 2023, Figure 1.8.
- The greatest relative increase in 2023 was observed for doxycycline (J01AA02) with an increase of 21.1% compared to 2022. Sales of amoxicillin (J01CA04) and amoxicillin with clavulanic acid (J01CR02) decreased by 21.6% and 12.5% respectively compared to 2022, Figure 1.8.
- Sales of antibiotics commonly used to treat RTIs increased the most for children aged 7-19 years, with a 42% increase in 2023 compared to 2022. Sales increased most during the first quarter of 2023 compared to 2022 for all age groups, Figure 1.9.

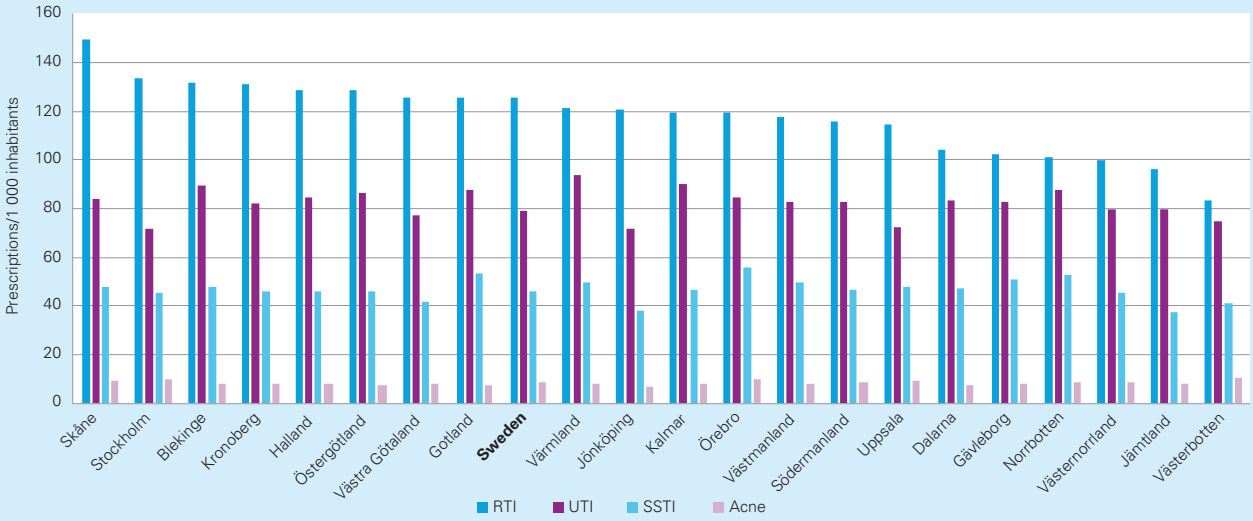
Figure 1.6. Sales of antibiotics commonly used to treat respiratory tract infections (RTI), urinary tract infections (UTI), skin and soft tissue infections (SSTI) and acne vulgaris in outpatient care from 2019 to 2023, by month[a].



[a]RTI:doxycycline (J01AA02); excluding packages larger than 50 tablets, penicillin V (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE, excluding ceftibuten J01DD14), and macrolides (J01FA); UTI: pivmecillinam (J01CA08), trimethoprim (J01EA01), ciprofloxacin (J01MA02), norfloxacin (J01MA06) until 2020, and nitrofurantoin (J01XE01); SSTI: clindamycin (J01FF01) and flucloxacillin (J01CF05); acne vulgaris: doxycycline (J01AA02; packages over 50 tablets), lymecycline (J01AA04), oxytetracycline (J01AA06) and tetracycline (J01AA07)

Source: The Public Health Agency of Sweden

Figure 1.7. Sales of antibiotics commonly used to treat respiratory tract infections (RTI), urinary tract infections (UTI), skin and soft tissue infections (SSTI) and acne vulgaris in outpatient care 2023, by region[a].



[a]RTI:doxycycline (J01AA02); excluding packages larger than 50 tablets), penicillin V (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE, excl ceftibuten J01DD14) and macrolides (J01FA); UTI: pivmecillinam (J01CA08), trimethoprim (J01EA01), ciprofloxacin (J01MA02), norfloxacin (J01MA06) until 2020 and nitrofurantoin (J01XE01); SSTI: clindamycin (J01FF01) and flucloxacillin (J01CF05); acne vulgaris: doxycycline (J01AA02; packages over 50 tablets), lymecycline (J01AA04), oxytetracycline (J01AA06) and tetracycline (J01AA07).

Source: The Public Health Agency of Sweden

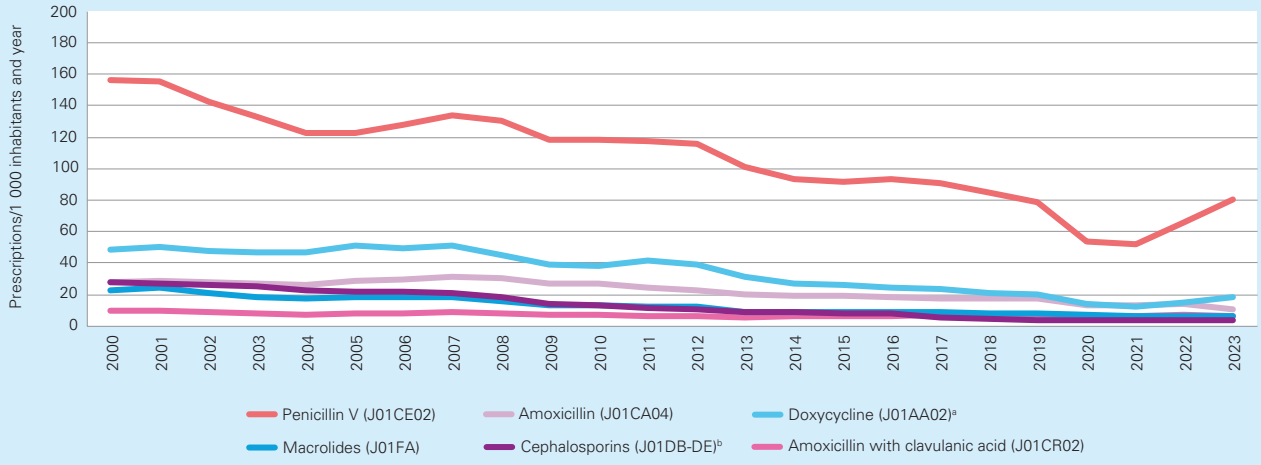
Comments

The recommended first-line treatment for lower RTIs in Sweden is penicillin V (J01CE02) (Medical Products Agency, 2008). In 2023, the sales of antibiotics commonly used to treat RTIs were higher than in 2022 but the total sales did not reach pre-pandemic levels. Trend analysis based on data since the 2000s showed a significant decrease ($p < 0.001$) in the sales of all RTI antibiotics in the recent years, except for amoxicillin with enzyme inhibitor (J01CR02), for which trend analysis showed a marginal increase since 2018.

Shortages of specific antibiotics may influence antibiotic sales patterns, possibly resulting in prescription of broader spectrum antibiotics. Oral solutions commonly prescribed to children have been particularly exposed to shortages. In 2023, shortages were observed for amoxicillin and amoxicillin with clavulanic acid in Sweden, which explains the reduction observed in sales.

The sales of antibiotics commonly used to treat RTIs increased most in the beginning of the year and returned to levels seen prior to the COVID-19 pandemic. The increasing number of respiratory infections in society in general during this period likely contributed to this increase. This peak in sales of antibiotics commonly prescribed against RTIs was largely driven by an increase in prescription to children aged 7-19 years. A clear disruption in seasonal patterns can be observed, especially for children, following the onset of the COVID-19 pandemic and continuing into the first quarter of 2023.

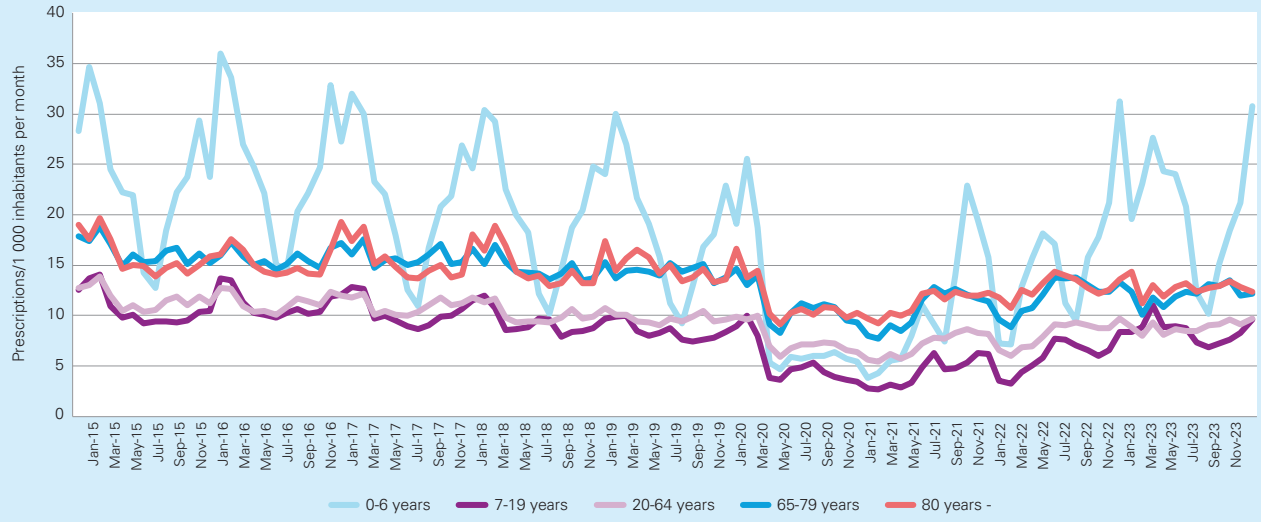
Figure 1.8. Sales of antibiotics commonly used to treat respiratory tract infections in outpatient care between 2000 and 2023.



[a]Doxycycline (J01AA02) excluding packages with more than 50 tablets.
[b]Ceftibuten (J01DD14) excluded.

Source: The Public Health Agency of Sweden

Figure 1.9. Sales of antibiotics commonly used to treat respiratory tract infections[a] in outpatient care from 2015 to 2023, per month.



[a]Includes doxycycline (J01AA02), penicillin V (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE), and macrolides (J01FA).

Source: The Public Health Agency of Sweden

Urinary tract infections (UTIs)

Results

- Sales of antibiotics commonly used to treat UTIs increased by 1.6% in 2023 among women aged 15-79 compared to 2022. Sales of ciprofloxacin (J01MA02) and trimethoprim (J01EA) decreased by 0.5% and 1.1%, respectively, whereas pivmecillinam (J01CA08) and nitrofurantoin (J01XE) increased by 0.7% and 3.6%, respectively, Figure 1.10.
- In men aged 65 or older, the sales of antibiotics commonly used to treat UTIs increased by 2.2% in 2023 compared to 2022. The greatest relative change was observed for pivmecillinam (J01CA08), which increased by 8.9%, and for trimethoprim with sulphonamides (J01EE), which increased by 7.6%, Figure 1.11.
- At the national level, 11% of the antibiotics commonly prescribed for UTIs in women aged 18-79 in 2023 consisted of ciprofloxacin. This proportion ranged from 7.7% in Jönköping region to 14.5% in Västerbotten region, Figure 1.12.

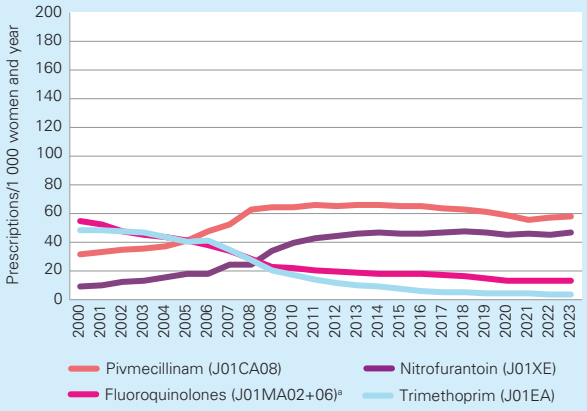
Comments

According to national treatment recommendations, pivmecillinam and nitrofurantoin are first-line treatments for UTIs in women aged 15 or older and in men with afebrile symptomatic UTIs (Medical Products Agency, 2017).

In line with treatment recommendations, 86% of the UTI antibiotics sold to women aged 15-79 in 2023 consisted of these two antibiotics. In men aged 65 or older, fluoroquinolones made up 37.3% of the UTI antibiotics sold in 2023. However, since the mid-2000s, sales of fluoroquinolones decreased and sales of pivmecillinam and nitrofurantoin increased in this population, according to trend analysis. Note that since 2021, norfloxacin (J01MA06) has been removed from the market and only ciprofloxacin (J01MA02) remains among the fluoroquinolones.

Strama has proposed a number of quality indicators in outpatient care, including that a maximum of 10% of antibiotics prescribed to treat UTIs in women aged 18-79 years consist of fluoroquinolones (Strama, 2016). This target was achieved by 2 of 21 regions in 2023, the same as the year before.

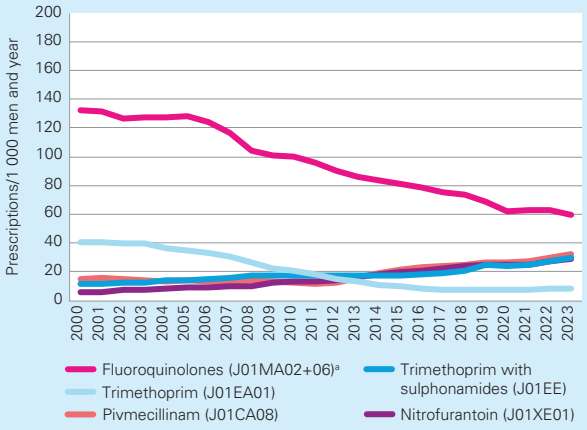
Figure 1.10. Sales of antibiotics commonly used to treat urinary tract infections in women aged 15-79 years in outpatient care between 2000 and 2023.



aFrom 2021, only ciprofloxacin (J01MA02) is represented in the group fluoroquinolones.

Source: The Public Health Agency of Sweden

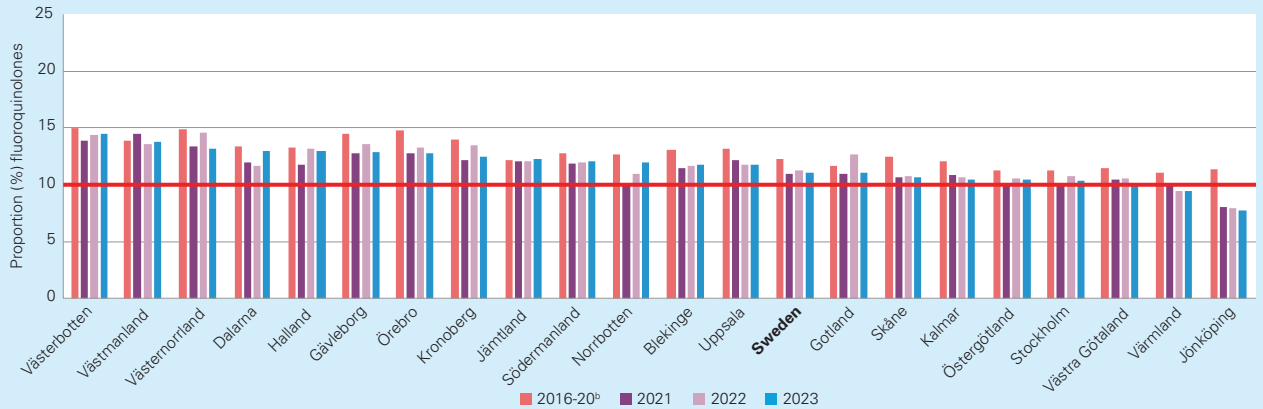
Figure 1.11. Sales of antibiotics commonly used to treat urinary tract infections in men aged 65 years or older in outpatient care between 2000 and 2023.



aFrom 2021, only ciprofloxacin (J01MA02) is represented in the group fluroquinolones.

Source: The Public Health Agency of Sweden

Figure 1.12. Proportion of fluoroquinolones (ciprofloxacin, J01MA02; norfloxacin, J01MA06, until 2020) among antibiotics commonly used to treat urinary tract infectionsa in women aged 18-79 years in outpatient care from 2016 to 2023, by region.



aPivmecillinam (J01CA08), trimethoprim (J01EA01), ciprofloxacin (J01MA02), norfloxacin (J01MA06) until 2020, and nitrofurantoin (J01XE01).
bAverage proportion is presented for the time period 2016-20. The red line indicates Strama's target of maximum 10% fluoroquinolones.

Source: The Public Health Agency of Sweden

Age and gender comparisons

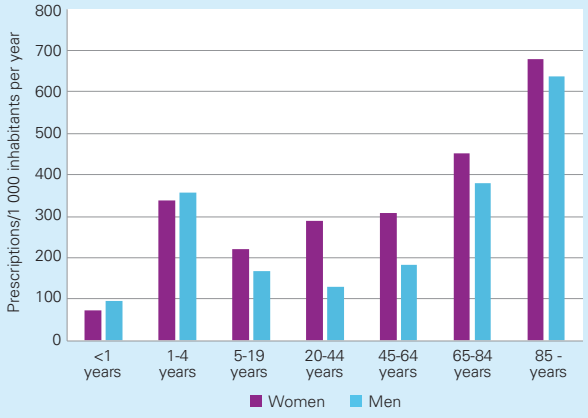
Results

- The rate of antibiotic prescriptions in outpatient care increased during 2023 but followed the same pattern as during 2022 i.e. the highest prescription rates were observed for people aged 85 years or older; 681 prescriptions per 1 000 inhabitants in women and 638 prescriptions per 1 000 inhabitants in men in 2023, Figure 1.13. 61% of all antibiotic prescriptions during 2023 were issued to women, the same as the year before.
- The most frequently prescribed antibiotics to children aged 1-4 were antibiotics commonly used to treat RTIs, representing 83% of the total antibiotic sales in this age group. RTI antibiotics were prescribed more to women than to men, except in the youngest and oldest age groups, Figure 1.14.
- Antibiotics commonly used to treat UTIs are mostly prescribed to women, and the prescription rate increases with age, Figure 1.15.
- Sales of antibiotics commonly used to treat SSTIs were highest for the oldest age groups, and prescriptions to men exceed those to women in these age groups, Figure 1.16.
- Antibiotics commonly used to treat acne are mainly used in the age groups 5-44 years and predominately by women, Figure 1.17. Most of the prescriptions are found among 15-19 year-olds (data not shown).

Comments

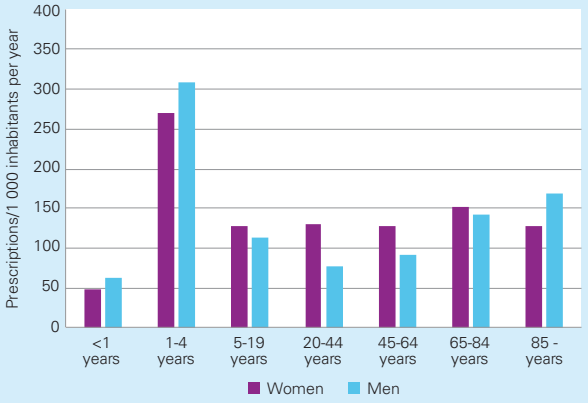
Concerning antibiotics commonly used to treat SSTIs and acne or similar skin conditions, older patients are more often prescribed longer treatments, which impacts the amount of antibiotics used. In general, comparisons across age groups show that antibiotics are used more in the older age groups. As mentioned in the *Guidance for readers*, some of the antibiotics used among the elderly population are not included in the outpatient care statistics as some medicines are sold on requisition and included in inpatient care statistics. Therefore, a possible underestimation in the oldest age groups cannot be ruled out.

Figure 1.13. Sales of antibiotics (J01 excl. methenamine) in outpatient care in 2023, by age and gender.



Source: The Public Health Agency of Sweden

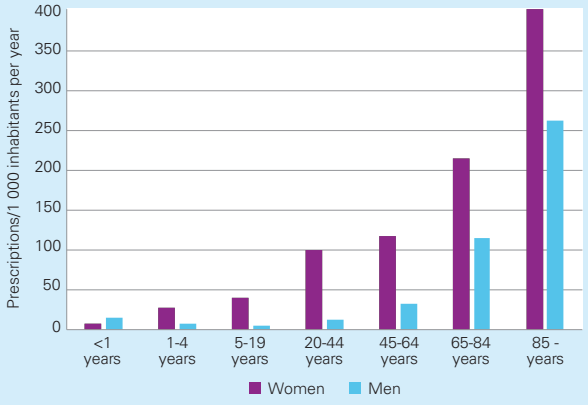
Figure 1.14. Sales of antibiotics commonly used to treat respiratory tract infections (RTIs)[a] in outpatient care in 2023, by age and gender.



[a]Doxycycline (J01AA02; excluding packages larger than 50 tablets), penicillin V (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE, excluding ceftibuten), and macrolides (J01FA).

Source: The Public Health Agency of Sweden

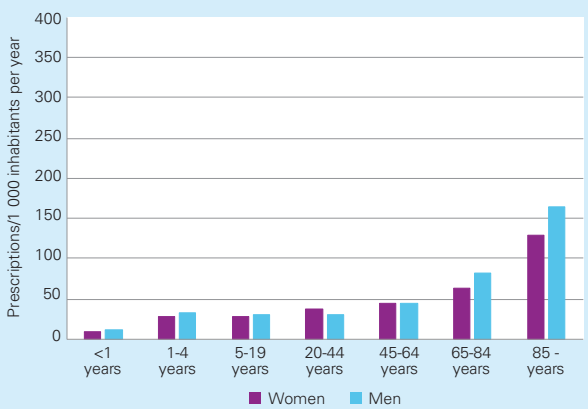
Figure 1.15. Sales of antibiotics commonly used to treat urinary tract infections[a] in outpatient care in 2023, by age and gender.



[a]Pivmecillinam (J01CA08), trimethoprim (J01EA01), ciprofloxacin (J01MA02), norfloxacin (J01MA06) until 2020, and nitrofurantoin (J01XE01).

Source: The Public Health Agency of Sweden

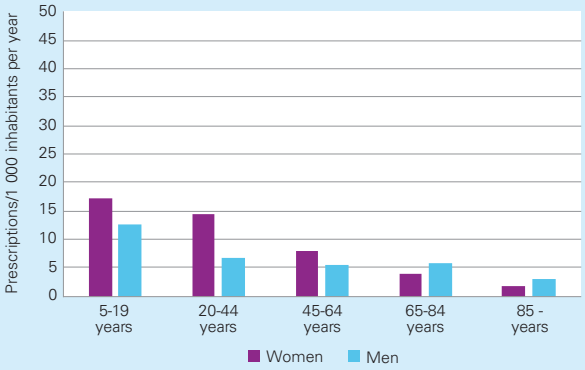
Figure 1.16. Sales of antibiotics commonly used to treat skin and soft tissue infections[a] in outpatient care in 2023, by age and gender.



[a]Clindamycin (J01FF01) and flucloxacillin (J01CF05).

Source: The Public Health Agency of Sweden

Figure 1.17. Sales of antibiotics commonly used to treat acne vulgaris[a] in outpatient care in 2023, by age and gender.



[a]Doxycycline (J01AA02); packages over 50 tablets, lymecycline (J01AA04), oxytetracycline (J01AA07) and tetracycline (J01AA07).

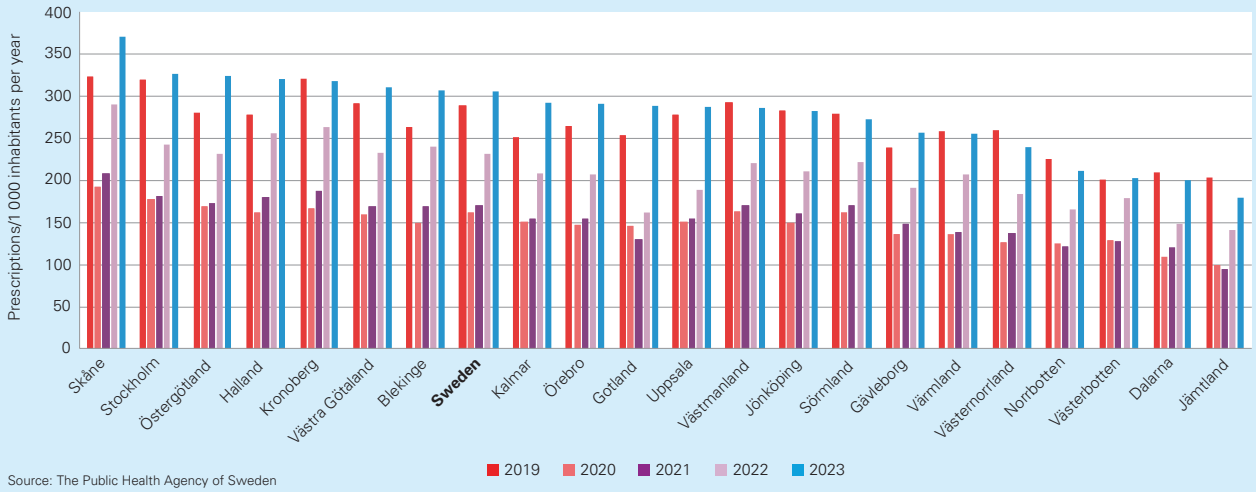
Source: The Public Health Agency of Sweden

Antibiotic sales in children

Results

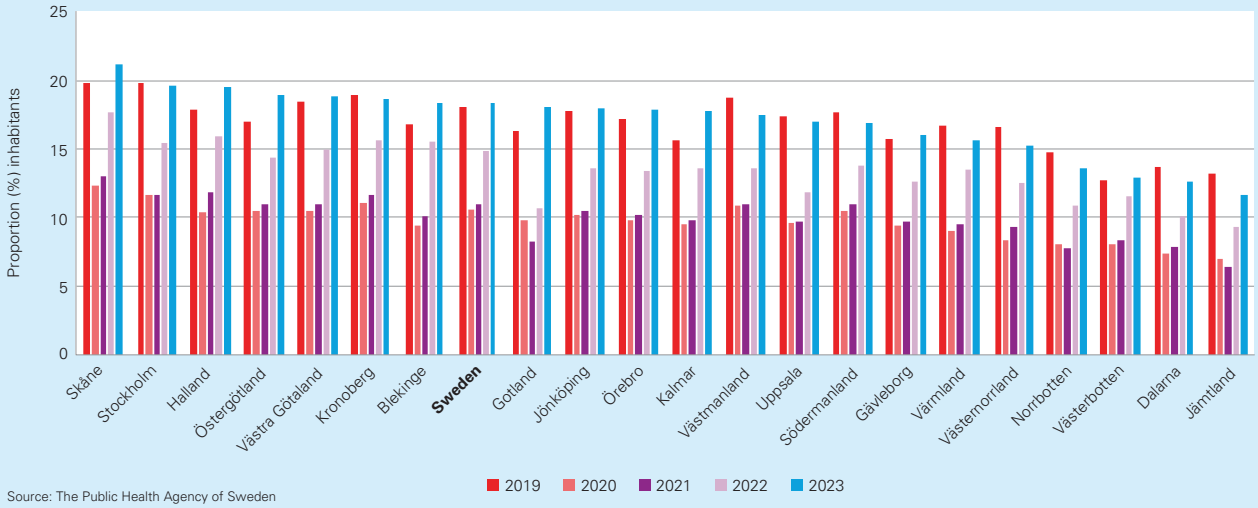
- Sales of antibiotics for children aged 0-6 years were 31.7% higher in 2023 than in 2022.
- The sales of antibiotics for children aged 0-6 years increased in all 21 regions in Sweden. There were large variations between regions, from 369 prescriptions per 1 000 children in Skåne region to 178 in Jämtland region in 2023, Figure 1.18.
- The most sold antibiotics for children aged 0-6 years were beta-lactamase sensitive penicillins (J01CE), which constituted 63% of the sales measured as prescriptions/1 000 inhabitants (data not shown).
- The proportion of children aged 0-6 years treated with at least one course of antibiotics increased in 2023 compared to 2022 and was estimated to 18.4%, Figure 1.19.

Figure 1.18. Sales of antibiotics (J01 excl. methenamine) to children aged 0-6 years in outpatient care between 2019 and 2023, by region.



Source: The Public Health Agency of Sweden

Figure 1.19. Proportion (%) of children aged 0-6 years treated with at least one course of antibiotics (J01 excl. methenamine) in outpatient care between 2019 and 2023, by region.



Source: The Public Health Agency of Sweden

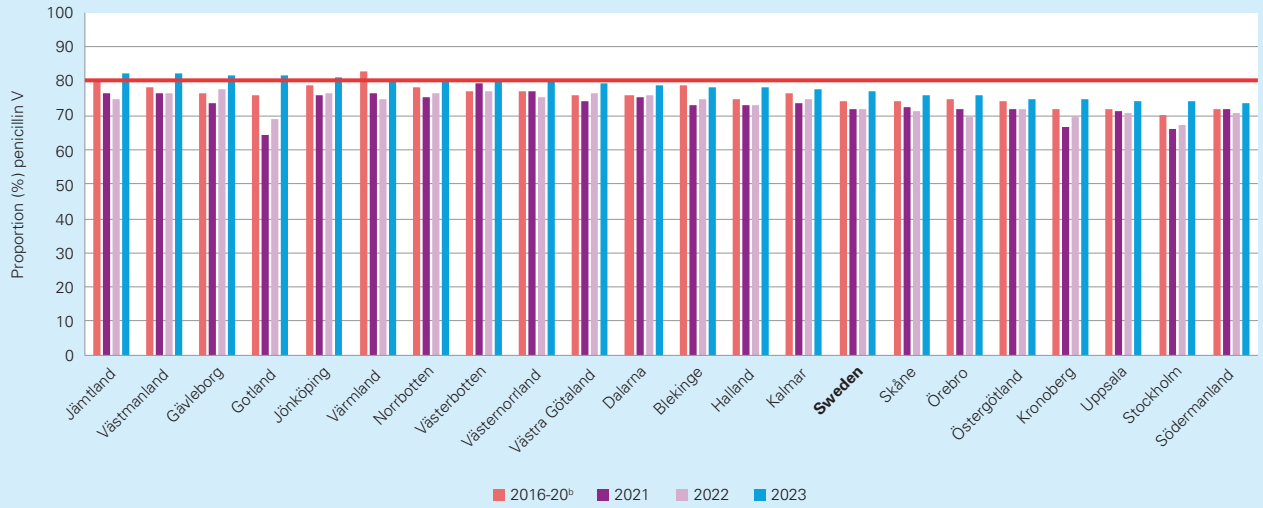
- At the national level, 77% of antibiotics commonly used to treat RTIs in children aged 0-6 consisted of penicillin V. This proportion ranged from 74% in Södermanland region to 82% in Jämtland region, Figure 1.20.

Comments

The sales of antibiotics to children aged 0-6 years have increased in all of the regions in Sweden during 2023 compared to 2022. Prescriptions rates in this group are higher nationally and in 12 regions than levels observed prior to the COVID-19 pandemic.

According to Strama's proposed quality indicator for outpatient care, at least 80% of antibiotics prescribed for RTIs in children aged 0-6 years should consist of penicillin V (Strama, 2016). To calculate this indicator, the following antibiotics are included in the denominator: amoxicillin (J01CA04), penicillin V (J01CE02), amoxicillin with clavulanic acid (J01CR02), cephalosporins (J01DB-DE, excluding ceftibuten J01DD14), doxycycline (J01AA02; excluding packages larger than 50 tablets) and macrolides (J01FA). In 2023, 9 of the 21 regions achieved this target.

Figure 1.20. Proportion (%) penicillin V (J01CE02) of antibiotics commonly used to treat respiratory tract infections[a] in children aged 0-6 years in outpatient care between 2016 and 2023, by region.



[a]Doxycycline (J01AA02, excluding packages larger than 50 tablets), penicillin (J01CE02), amoxicillin (J01CA04), amoxicillin with enzyme inhibitor (J01CR02), cephalosporins (J01DB-DE, excluding ceftibuten) and macrolides (J01FA). [b]Average proportion is presented for the time period 2016-2020. The red line indicates Strama's target of at least 80% penicillin V.

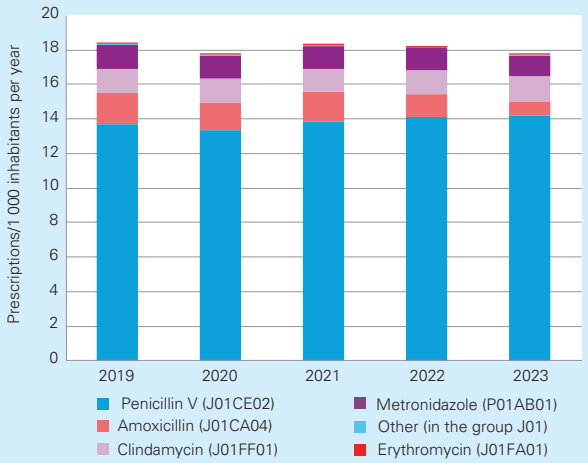
Source: The Public Health Agency of Sweden

Antibiotics in dentistry

Results

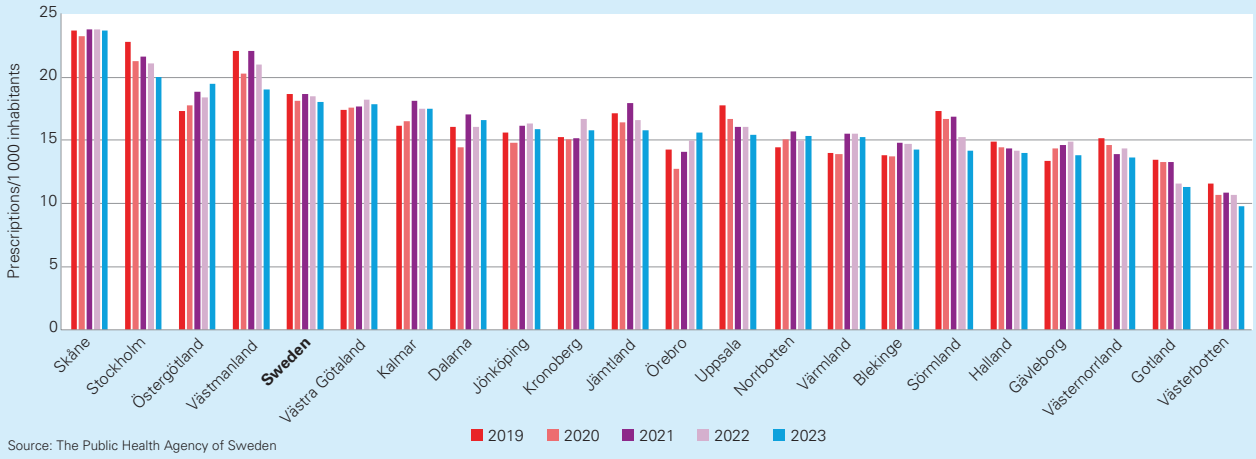
- Dentists accounted for 6.1% of all systemic antibiotics (J01 excl. methenamine) sold in Sweden in 2023, a decrease from 6.6% in 2022.
- Sales of antibiotics (J01 excl. methenamine; metronidazole P01AB01) prescribed by dentists in 2023 was estimated to 18 prescriptions per 1 000 inhabitants, a decrease by 2.6% compared to the year before, Figure 1.21.
- The most commonly prescribed antibiotic by dentists was penicillin V (78.5% of total sales), Figure 1.21. Compared to 2022, the sales of clindamycin and penicillin V increased by 4.7% and 0.2%, respectively, whereas the sales of other antibiotics decreased. Sales of amoxicillin (J01CA04) decreased the most, by 34.7%.
- Sales of antibiotics prescribed by dentists decreased in 17 of 21 regions during 2023. There were notable regional differences; dentists in Skåne region issued 24 prescriptions per 1 000 inhabitants, more than double that of dentists in Västerbotten region (10 prescriptions per 1 000 inhabitants), Figure 1.22.

Figure 1.21. Sales of antibiotics prescribed by dentists in outpatient care between 2019 and 2023.



Source: The Public Health Agency of Sweden

Figure 1.22. Sales of antibiotics (J01 incl. methenamine; metronidazole P01AB01) prescribed by dentists in outpatient care between 2019 and 2023, by region.



Source: The Public Health Agency of Sweden

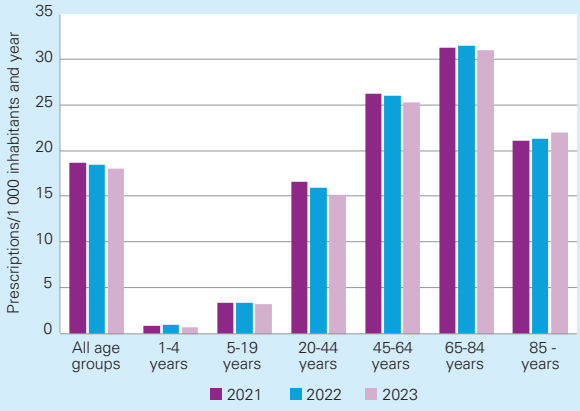
- Prescriptions decreased for all age groups except for patients older than 85 years of age, where sales increased by 3%. Sales decresead the most for patients aged 1-4 years (13.4%). Most antibiotics were prescribed to those aged 65-84 years, followed by the age group 45-64 years, Figure 1.23.

Comments

The decline in antibiotic prescriptions observed in 2020 may have been the result of fewer dental care visits, especially among the elderly (National Board of Health and Welfare, 2022). Following this decrease in antibiotic prescribing by dentists, prescription levels appear to have returned to a pre-pandemic level and stabilised during 2022 and 2023 with smaller changes observed, despite a continued reduction of dental care visits in 2021 (National Board of Health and Welfare, 2022). This effect of the pandemic was most apparent in antibiotic prescriptions for the two oldest age groups. However, for patients older than 85 years of age, antibiotic prescribing by dentists remained higher than levels observed in 2019. Prescriptions to patients below the age of 1 are not shown, as no antibiotics were prescribed by dentists to patients in this age group during 2023.

Penicillin V was the most commonly prescribed antibiotic by dentists, which is in line with treatment recommendations (Medical Products Agency, 2014). Metronidazole is also recommended as first-line treatment in combination with penicillin V to attain a broader anaerobic spectrum and is therefore included in the measure of sales. The low levels of erythromycin prescription continue to decrease. Shortages were observed for both amoxicillin and amoxicillin with clavulanic acid in Sweden during 2023, which can explain the decrease of sales of these antibiotics. Clindamycin was recommended as an alternative prophylactic treatment in dental care due to amoxicillin shortages, which explains the increase observed in sales for this substance (Janusinfo, 2023).

Figure 1.23. Sales of antibiotics (J01 incl. methenamine; metronidazole P01AB01) prescribed by dentists in outpatient care between 2021 and 2023, by age group.



Source: The Public Health Agency of Sweden

Antibiotics in inpatient care

Data in this section include sales to all Swedish hospitals, some but not all nursing homes, and other institutions within health- and social care that procure antibiotics for dispensing to patients or residents. Of the total sales in inpatient care, the proportion of antibiotics dispensed to acute care hospitals varies from region to region. Some challenges associated with this procurement data are further described in *Guidance to readers*. Due to regulations regarding confidentiality of sales data, detailed data for specific substances and groups cannot be shown. However, relevant trends over time are described in text.

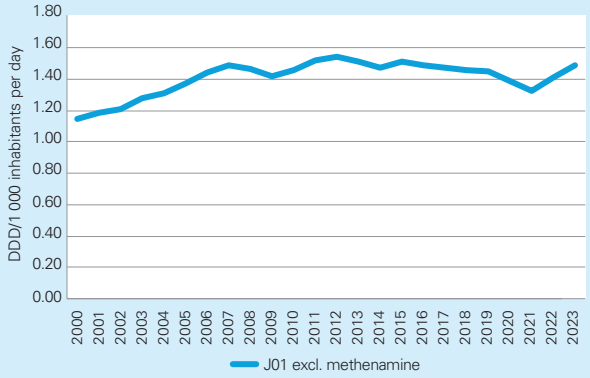
The segment previously presented in this section regarding sales of antibiotics in to acute care hospitals has been removed from this year's report due to current regulations regarding confidentiality of sales data. Antibiotic consumption data from a point prevalence study (PPS) of healthcare-associated infections and antibiotic use in acute care hospitals in the spring of 2023 have been described in an In Focus.

Antibiotic sales in hospitals and other health- and social care facilities

Results

- Total sales of antibiotics (J01 excl. methenamine) to hospitals and other health- and social care facilities were 1.5 DDD/1 000 inhabitants per day in 2023, a 5.7% increase compared to 2022, Figure 1.24.
- Sales of antibiotics in inpatient care increased in 20 of 21 regions during 2023, ranging from 1.2 DDD/1 000 inhabitants per day in Halland region to 1.9 prescriptions DDD/1 000 inhabitants per day in Kronoberg region, Figure 1.25.

Figure 1.24. Sales of antibiotics (J01 excl. methenamine) to hospitals and other health- and social care facilities between 2000 and 2023.



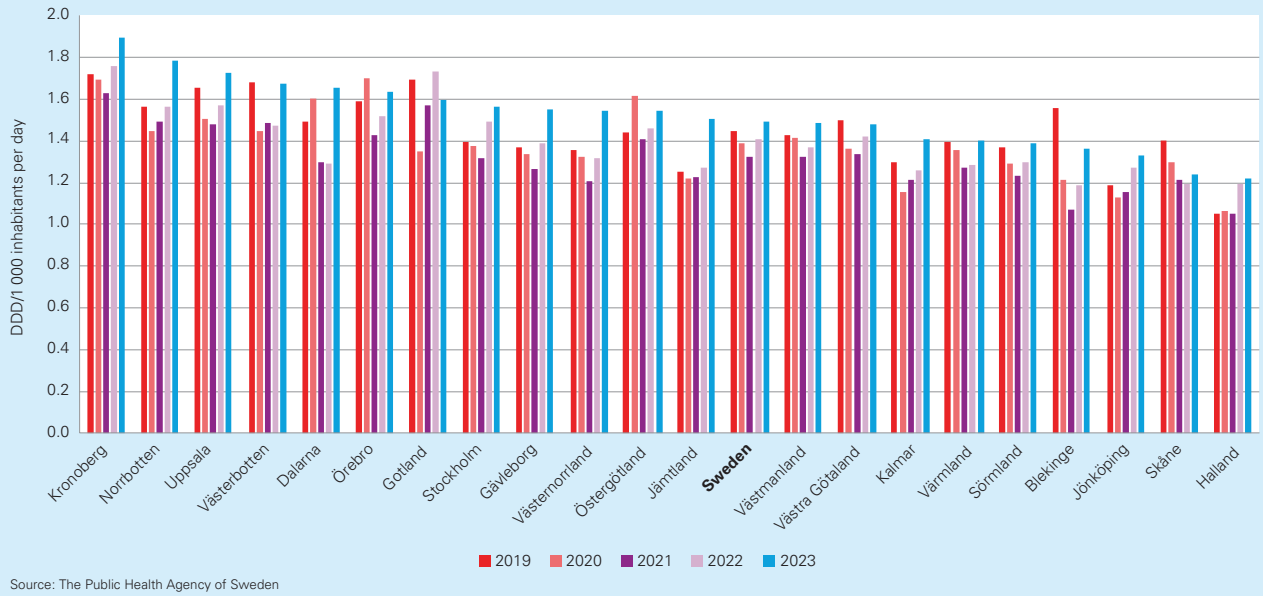
Source: The Public Health Agency of Sweden

Comments

While antibiotic sales to hospitals and other health- and social care facilities have been relatively stable over the last decade before the COVID-19 pandemic, the observed increase in 2022 and 2023 could be due in part to effects of the pandemic during 2020 and 2021. Substances such as penicillins (J01CE and J01CF) are often used as prophylaxis (Skoog et al., 2016) and a decreased number of surgeries during the COVID-19 pandemic may have reduced the use of these substances (National Board of Health and Welfare, 2021). However, a decrease in sales to hospitals and other health- and social care facilities during 2020 and 2021 was not observed for all antibiotics. For example, sales of combinations of penicillins (J01CR), specifically piperacillin-tazobactam, have shown a significant increase through the years 2000-2023 (data not shown). Sales of beta-lactamase resistant penicillins have shown an annual increase during the period 2000-2019 and an annual decrease during 2020-2022. An annual decrease was also observed for aminoglycosides during the period 2012-2023.

Regional differences in sales of antibiotics in inpatient care can reflect a variety of factors influencing sales. How regions procure antibiotics for nursing homes and other institutions within health- and social care that procure antibiotics for dispensing to patients or residents varies. There are also variations in the type of hospitals, case mix and patient demographics in the regions, and these factors should be taken into account when comparisons are made. For example, the regions Uppsala, Stockholm, Västerbotten, Västra Götaland, Skåne, Östergötland and Örebro all have tertiary referral hospitals with more advanced care.

Figure 1.25. Sales of antibiotics (J01 excl. methenamine) to hospitals and other health- and social care facilities between 2019 and 2023, by region.



Source: The Public Health Agency of Sweden

Swedish antibiotic prescribing according to the WHO AWaRe classification

WHO AWaRe classfication

The World Health Organization (WHO) introduced the AWaRe Classification of Antibiotics in 2017 as a tool to support antibiotic stewardship efforts locally and globally. Since then, it has been updated twice and most recently in 2021.

AWaRe classifies antibiotics into three groups based on their impact on antibiotic resistance, i.e. Access, Watch, and Reserve. The Access group includes first- and second-line treatments for common infections, and should be made widely accessible. The Watch group consists of broad-spectrum antibiotics that are used for specific, limited indications. This group includes most of the "highest priority" antibiotics on the WHO list of critically important antimicrobials for human medicine and veterinary use. Finally, the Reserve group includes last-resort antibiotics that should only be used for life-threatening infections caused by multi-drug resistant bacteria where other treatments have failed.

Watch and Reserve group antibiotics are recommended as targets for monitoring and stewardship programs, and the overall goal is to reduce their use. According to a target set by the WHO, at least 60% of all antibiotics consumed in each country should belong to the Access group by 2023. There are no separate targets for hospital and community consumption based on the AWaRe classification. In 2023, the Council of the European Union (EU) adopted new recommendations aimed to increase efforts to combat antimicrobial resistance, more information in the In Focus section (Council of the European Union, 2023). The recommendation included a slightly more ambitious national target for the percentage of consumption of Access group antibiotics of all the antibiotics listed in the AWaRe classification of at least 65%.

Consumption of Access, Watch, and Reserve antibiotics in Sweden from 2001-2021

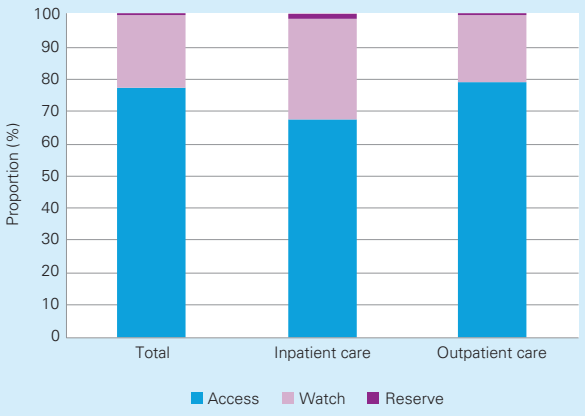
Based on data from electronic prescribing (outpatient care) and requisitions (inpatient care), 77.4% of antibiotics (J01 excluding methenamine J01XX05) sold in 2023 were Access antibiotics according to the most recent version of the AWaRe classification. Watch group antibiotics made up 22.3% of all antibiotics sold, and the remaining 0.26% consisted of Reserve group antibiotics. As expected, the proportion of Watch antibiotics was higher in inpatient care than in outpatient care, i.e. 31.4% versus 20.8% (Figure 1.26). Most Reserve antibiotics were sold to inpatient care, but a small proportion was also prescribed in outpatient care and consisted mainly of parenteral colistin, linezolid, aztreonam and daptomycin. The sector classified as "inpatient care" also includes antibiotics supplied to other care providers than hospitals, such as some elderly homes and dental care. Thus, it is reasonable to assume that the proportions of Watch and Reserve antibiotics used in hospitals may be higher in reality than the estimates presented here. In addition, due to the inability to include certain antibiotics prescribed and sold on license (see Methods section), it is reasonable to assume that the overall proportions of prescription for these antibiotics may be somewhat underestimated.

Over the last 20 years, the proportion of Access antibiotics has stayed stable between 77-80%, but a drop was observed during 2020 and 2021 in both outpatient and inpatient care as an effect of the COVID-19 pandemic (Figure 1.27a). Simultaneously, the proportion of Watch antibiotics increased, while the prescribing of Reserve antibiotics has gradually increased since the early 2000s (Figures 1.27b and 1.27c). Therefore, while the total consumption of antibiotics decreased during the COVID-19 pandemic, there seems to have been a shift towards broader spectrum antibiotics. In 2023, there was a slight increase in the proportion of Access antibiotics sold, as well as a slight decrease in the proportion of both Watch and Reserve antibiotic total sales.

Notably, the decrease observed for the proportion of Reserve antibiotics was observed only in outpatient care. The sales of Reserve antibiotics in both outpatient and inpatient care have not completely returned to levels observed before the pandemic. Further analysis over the following years is required to fully observe the effects of the COVID-19 pandemic on antibiotic prescribing according the AWaRe classification.

Sweden exceeds the WHO minimum target for Access antibiotics of 60% and the Council of the EU recommended national target for Access group antibiotics of at least 65%. Note that the Council of the EU used data from ESAC-Net, which includes methenamine (J01XX05) in AWaRe analysis (ECDC, 2023). Including methenamine, Sweden continues to exceed the Council of the EU recommended target of at least 65% Access group antibiotics. Although the consumption of Reserve group antibiotics seems to be low, the increased prescribing of these substances, especially in primary care, merits further review.

Figure 1.26. Relative consumption of Access, Watch and Reserve antibiotics in Sweden in 2023, total and divided by health-care sector.



Source: The Public Health Agency of Sweden

Figure 1.27 A. Relative consumption of Access antibiotics in Sweden between 2000-2023, total and divided by health-care sector.

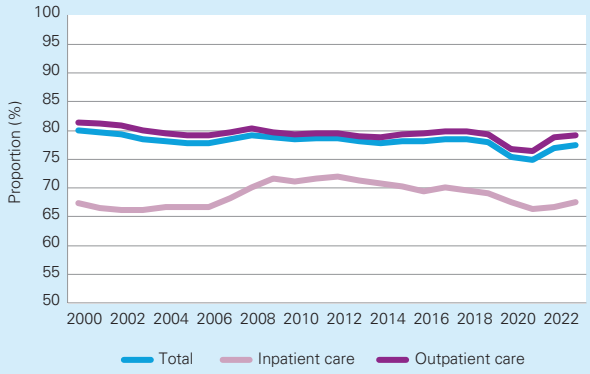


Figure 1.27 B. Relative consumption of Watch antibiotics in Sweden between 2000-2023, total and divided by health-care sector.

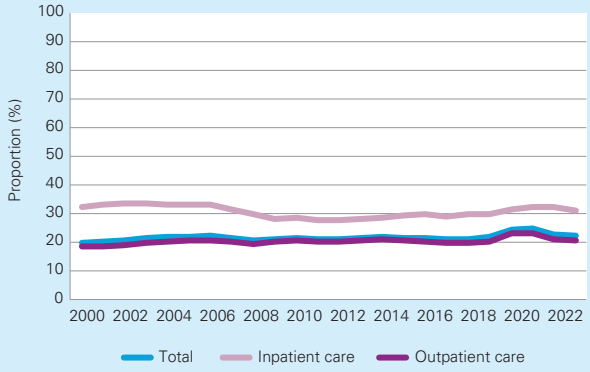
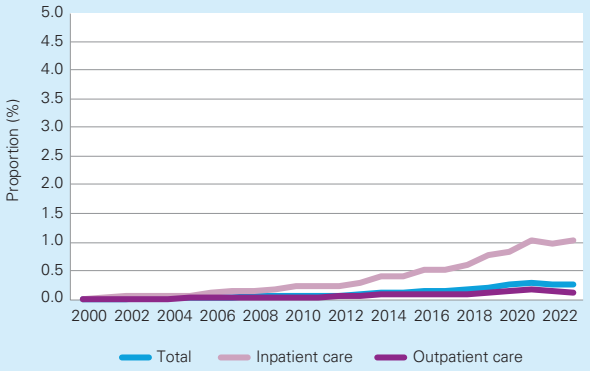


Figure 1.27 C. Relative consumption of Reserve antibiotics in Sweden between 2000-2023, total and divided by health-care sector.



Adverse reactions related to antibiotic use

Reported drug-related adverse reactions are continuously entered into BiSi, a national database administered by the Swedish Medical Products Agency. The reports originate both from healthcare professionals and patients. Adverse reactions related to antibiotics between 2019 and 2023 were analysed for various classes of agents.

There were 3 013 reports of side effects caused by the use of antibiotics during this period. The following organ system groups received most reports related to the use of systemic antibiotic drugs: skin- and subcutaneous tissue disorders (n=1 285), gastrointestinal disorders (n=835), general disorders (n=477), nervous system disorders (n=474), musculoskeletal disorders (n=207), respiratory disorders (n=189), and reproductive system and breast disorders (n=121), immune system disorders (n=118), investigations (n=116), infections and infestations (n=115), renal and urinary disorders (n=109), psychiatric disorders (n=106) and hepatobiliary disorders (n=102).

The majority of the reports (69%) concern female patients, which corresponds to the gender difference seen in sales of antibiotics. The ten antibiotic substances most commonly associated with adverse reactions in the last five years, unadjusted for sold substances and regardless of the cause of the report, are presented in Table 1.1.

Table 1.1. Substances most commonly associated with adverse reactions reported to the Swedish Medical Products Agency 2019-2023

Antibiotic	Total number of adverse drug reaction reports 2019-2023	Number of 'serious' reports	Number of fatal cases
Penicillin V (J01CE02)	397	76	0
Flucloxacillin (J01CF05)	270	123	4
Ciprofloxacin (J01MA02)	251	147	2
Nitrofurantoin (J01XE01)	238	62	1
Trimethoprim and sulphamethoxazole (J01EE01)	218	115	3
Clindamycin (J01FF01)	203	65	3
Doxycycline (J01AA02)	165	23	0
Amoxicillin (J01CA04)	159	46	0
Amoxicillin with enzyme inhibitor (J01CR02)	106	31	1
Pivmecillinam (J01CA08)	106	20	0

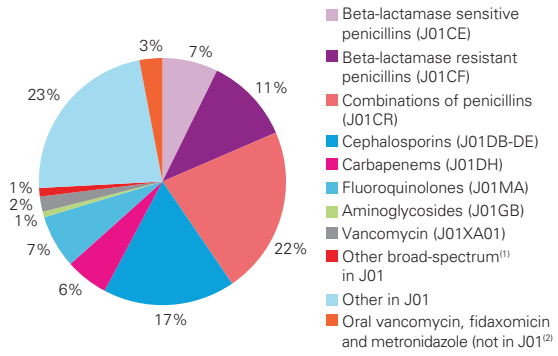
ECDC PPS 2023: Antibiotic use in acute-care hospitals in Sweden

In April and May of 2023, a point prevalence study (PPS) of healthcare-associated infections and antibiotic use was performed at 54 Swedish acute-care hospitals. The study was performed as part of a EU/EEA-wide survey initiated by the European Centre for Disease Prevention and Control (ECDC) approximately every five years (ECDC 2024). Results from the Swedish study were published at the end of 2023 (PHAS 2023). Participation was voluntary and all 21 regions in Sweden were represented with at least one hospital, including all seven university hospitals in Sweden. In total, 13 588 patients were registered in the survey. All antibiotics included in the ATC category J01 as well as oral vancomycin, fidaxomicin and metronidazole (A07AA09, A07AA12 and P01AB01, respectively) were reported in the survey and are included in the antibiotic courses described in this section.

Antibiotic use in acute-care hospitals

At the time of the PPS, more than one third (36.1%) of all patients were on at least one course of antibiotics. Most antibiotic courses were administered intravenously (66.8%). Over half (53.4%) of all registered antibiotic courses were with broad-spectrum[1] antibiotics. Piperacillin-tazobactam (J01CR05) was the most commonly registered antibiotic in the PPS, followed by cefotaxime (J01DD01), cloxacillin (J01CF02), trimethoprim-sulfamethoxazole (J01EE01) and benzylpenicillin (J01CE01), in that order. By ATC3 class, penicillins (J01C) were the most common (47.0%) followed by cephalosporins and carbapenems (J01D, 23.7%) (Figure 1).

Figure 1. Distribution of registered antibiotic courses according to ATC-classification.

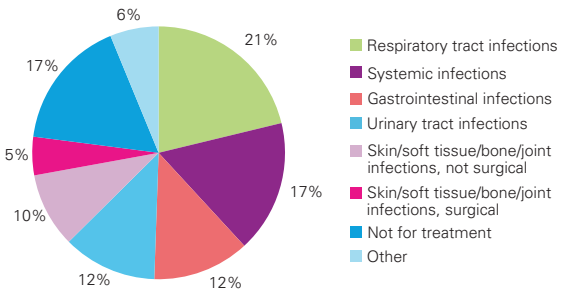


Antibiotic use linked to diagnosis

The most common diagnoses registered for antibiotic courses in the PPS were pneumonia and lower respiratory tract infections (21.2%), systemic infections (16.9%), gastrointestinal infections (12.4%) and urinary tract infections (12.0%) (Figure 2).

Nearly half of all registered antibiotic courses were prescribed for community-acquired infections (49.1%) while approximately a quarter of all registered antibiotic courses were for healthcare-associated infections and infections from long-term care facilities (24.4%). Prophylaxis (surgical and medical) made up 18.6% of all antibiotic use and almost one third of all surgical prophylaxis lasted more than one day.

Figure 2. Diagnoses for registered antibiotic courses (n=5660).



Antibiotic stewardship indicators for inpatient care

NAG Strama (the National working group of the Swedish strategic programme against antibiotic resistance) has compiled a set of quality indicators for antibiotic use in inpatient care for stewardship purposes (NAG Strama 2022). These quality indicators are meant to help improve the use of antibiotics in a hospital setting and cover a variety of parameters, including several for specific diagnoses and organisational factors. Note that these quality indicators are not designed for PPS data but rather to follow-up for example data on incidence that is continously collected.

[1] Following antibiotics were considered broad-spectrum in the study: tigecycline (J01AA12), piperacillin-tazobactam (J01CR05), cephalosporins (J01DB-J01DE), carbapenems (J01DH), other cephalosporins and penems (J01DI), fluoroquinolones (J01MA), glycopeptides (J01XA), colistin (J01XB01), linezolid (J01XX08) and daptomycin (J01XX09).

[2] Following oral antibiotics outside of the J01 ATC-group were included: vancomycin, fidaxomicin and metronidazole (A07AA09, A07AA12 and P01AB01, respectively).

Quality indicator for treatment of afebrile UTI

Strama quality indicators for antibiotic use in inpatient care include a quality indicator for afebrile urinary tract infections (UTI), with separate targets for men and women. This quality indicator tracks the proportion of quinolones (J01MA) out of antibiotics prescribed for afebrile UTI, i.e. quinolones (J01MA), pivmecillinam (J01CA08), nitrofurantoin (J01XE01) and trimethoprim (J01EA01). The target for women is less than 10% quinolones and the target for men is less than 30% quinolones. At 12.6% and 37.3% respectively, neither target was met in this study. In addition, the targets were not met when considering only patients without urinary catherters (11.9% and 33.3% for women and men, respectively). Note, the PPS did not use the term "afebrile UTI" that is used in the Strama quality indicators, but rather "cystitis". In this analysis, the two terms have been considered interchangeable.

Indicators for treatment of community-acquired pneumonia

Strama quality indicators for antibiotic use in inpatient care include an indicator for community-acquired pneumonia. This quality indicator tracks the proportion of benzylpenicillin (J01CE01) out of antibiotics prescribed for community-acquired pneumonia, i.e. benzylpenicillin (J01CE01), cefotaxime (J01DD01), piperacillin-tazobactam (J01CR05) and carbapenems (J01DH). For the PPS, this quality indicator was at 22.7%. While there is no clear target included, this quality indicator can be followed-up over time. When considering all antibiotics prescribed for community-acquired pneumonia, 54.2% were broad-spectrum[2] (Figure 4). While piperacillin-tazobactam (J01CR05) is only recommended in a very few cases in national antibiotic treatment guidelines for community-acquired pneumonia, more than one in six treatments was with piperacillin-tazobactam.

Figure 3 A. Strama quality indicator for afebrile UTI, for women

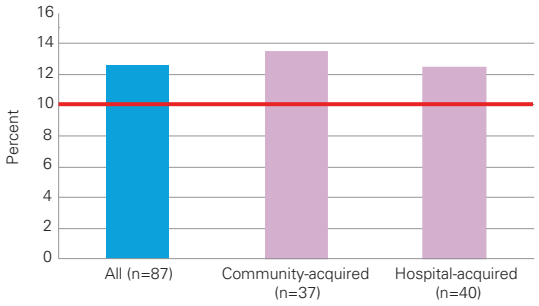


Figure 3 B. Strama quality indicator for afebrile UTI, for men

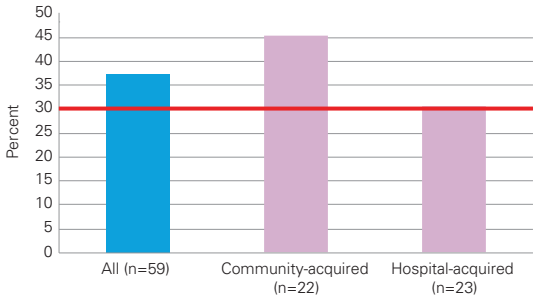
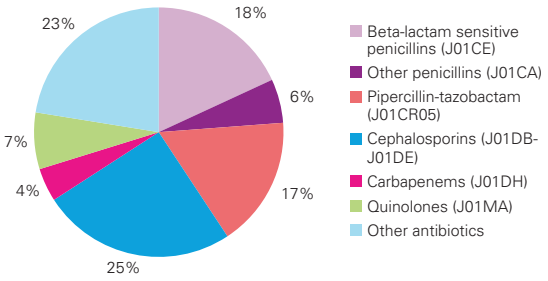


Figure 4. All antibiotics prescribed for community-acquired pneumonia (n=668)



Other quality indicators

One of Stramas quality indicators for antibiotic use in hospital care concerns personnel dedicated to antibiotic stewardship work, with a target of 0.1 full-time equivilent (FTE) per 100 beds. Of the 52 hospitals that answered questions regarding FTE dedicated to antibiotic stewardship, 36 hospitals (69.2%) did not fulfil this target.

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Ongoing activities to improve access to antimicrobials

Access to new and older medicines is a global and multifaceted problem. Few completely novel antibiotics are in the pipeline and measures to strengthen R&D, such as policies that increase and ensure return on investment for new antibiotics, are highly needed. Many new products are not marketed in countries with small markets.

Why is access to antimicrobials a challenge?

For many new and old approved antibiotics, there are shortages in many countries due to both financial reasons and vulnerable supply chains. There is a lack of transparency regarding where active pharmaceutical ingredients and finished dosage forms are produced, but production of these mainly takes place outside of EU. Furthermore, important older medicinal products are subjected to recurring shortage situations and have a risk of being deregistered from small markets, mainly due to poor profitability. In Sweden and the other Nordic countries, this is particularly problematic for small-volume products with low profitability, such as narrow-spectrum agents and formulations primarily for young children.

What is a shortage?

A shortage situation occurs when a pharmaceutical company is temporarily unable to deliver a medicinal product so that supply meets demand. Medical products intended for humans often have several substitutable alternatives and can often be replaced directly at the pharmacy. Veterinary medical products have fewer alternatives. If no substitutable alternatives are available, which may be the case if there is only a single pharmaceutical company (Market Authorisation Holder) providing the product on the Swedish market, a shortage situation is classified as "critical".

National efforts

Several governmental initiatives are ongoing to address these challenges and need to be continuously prioritised. Shortage situations lead to extensive additional workload for both healthcare and pharmacy staff, as well as for patients and guardians. Critical shortages can lead to suboptimal treatments and inequality regarding treatment options nationwide. For antibiotics, there is a "reverse market logic" as a consequence of wise antibiotic stewardship, which entails that antibiotic use should be responsible and limited in order to reduce the development of resistance. Managing these issues requires a long-term perspective and special measures to strengthen access to both new and older antibiotic products. Efforts to increase access to antibiotics are an important part of the work against antibiotic resistance.

Several relevant national steering documents, such as the Joint authority action plan against antibiotic resistance 2021–2024 produced by the National intersectoral coordinating mechanism against antibiotic resistance as well as the Swedish strategy to combat antibiotic resistance, include objectives on access to antibiotics

Currently, intensive work by Swedish authorities is ongoing to promote access to antibacterial products (antibiotics):

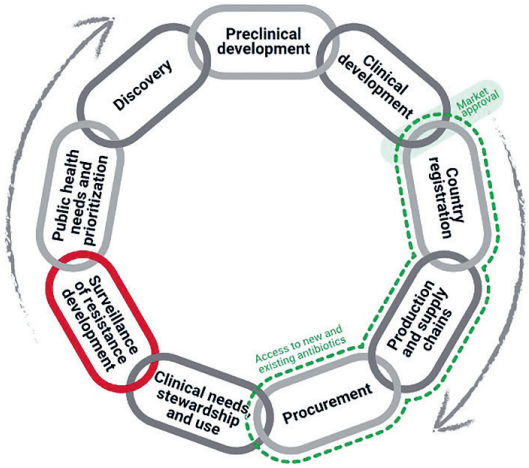
- The Public Health Agency of Sweden has implemented a new reimbursement model to ensure availability of new, medically important antibiotics and has ongoing work to develop a financial and logistic model to create incentives for companies to provide a turnover stock of prioritised prescription antibiotics.
- The Swedish Medical Products Agency and The Dental and Pharmaceutical Benefits Agency, respectively, have several ongoing assignments and initiatives for medicinal shortages, in general and specifically for antibiotics, regarding communication, regulatory opportunities, adjustment of ceiling prices and creation of turnover stocks with the intention of preventing the occurrence and serious consequences of medicine shortage situations.
- The collaboration platform Platinea (which represents academia, health care, authorities and industry) works with accessibility issues regarding antibiotics from a broad perspective.

International efforts

Internationally, several important initiatives aim to improve access to antibiotics:

- The European Commission's cross-sectoral action plan against antibiotic resistance, the European Commission's Council recommendations on the intensification of EU action to combat antimicrobial resistance through a One Health model, the European Commission's proposal for a new regulation and a new directive for the reform of EU medicines legislation presented in April 2023.
- Sweden, together with Norway, is currently leading a work package focusing on implementing measures against lack of access to existing antibiotics within Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections 2 (EU-JAMRAI 2), a program within EU4Health, where several authorities and other stakeholders from 14 countries are participating.
- Efforts are also needed to stimulate research and development in the field of antibiotics. Sweden leads a working group within WHO's recently started Novel Medicines Platform (NMP), with a focus on policies aimed at sustainable development and access to new antimicrobial medicines. Continued cooperation and exchange of experience nationally, within the Nordic region and on a European and global level is crucial in order to deal with insufficient access to antimicrobials.

Figure 1. The antibiotic research & development and access chain.



Council recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach

In June 2023, the Council (EPSCPO) adopted the Council Recommendation on stepping up EU action to combat antimicrobial resistance, based on the proposal presented by the European Commission.

The Council Recommendation aims to encourage the prudent use of antimicrobials in human and animal health through a series of voluntary measures and to reduce the risk of microorganisms becoming resistant to microbial treatment.

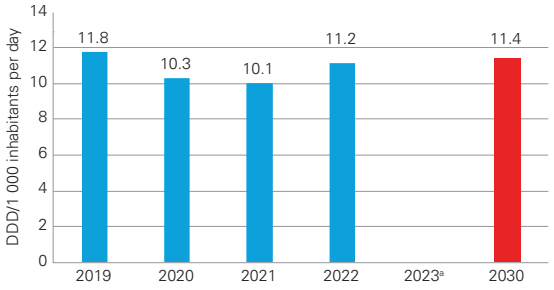
The recommendation contains a number of measures in various areas:

- National Action Plans against AMR.
  - Have in place, implement and regularly update National Action Plans against AMR based on the One Health approach.
  - Allocate appropriate human and financial resources for the effective implementation of the National Action Plans.
  - Evaluate, regularly and at least every three years, the outcomes of the National Action Plans and take actions to address the findings of these evaluations and other relevant inputs.
  - Ensure that National Action Plans and the regular evaluation of their outcomes are publicly available within six months after completion of the evaluation.
- Surveillance and monitoring of AMR and antimicrobial consumption (AMC).
  - Close existing surveillance and monitoring gaps and ensure completeness of data, including real-time data and timely access to data where appropriate, by 2030, on both AMR and AMC at all levels.
- Infection prevention and control.
  - Ensure that infection prevention and control measures in human health are put in place and continuously monitored to contribute to limiting the spread of antimicrobial resistant pathogens.
- Antimicrobial stewardship and prudent use of antimicrobials.
- Recommended targets for antimicrobial consumption and antimicrobial resistance.
- Awareness, education and training.
- Research & development and incentives for innovation and access to antimicrobials and other AMR medical countermeasures.
- Cooperation.
  - Report data on AMR and on antimicrobial consumption to the Global Antimicrobial Resistance and Use Surveillance System (GLASS) and to improve the One Health approach on AMR.
- Global.
  - Advocate for AMR to feature as a high political priority in G7 and G20 settings, leading to ambitious commitments at global level, including to fairly share, among the G20 or G7 countries, the financial burden arising from push and pull incentives for antimicrobials.
  - Work towards preventing AMR through the One Health approach by strengthening capacities in cooperation with the Quadripartite.

Recommended targets for antimicrobial consumption and antimicrobial resistance for humans in EU and Sweden

- Take appropriate national measures aimed at ensuring that, by 2030, the total consumption of antibiotics in humans (in Defined Daily Dose (DDD) per 1 000 inhabitants per day), in the community and hospital sectors combined, including in long-term care facilities and in home-care settings, is reduced by 20% in the Union compared with the baseline year 2019. The national target for Sweden is a 3% reduction by 2030.

Figure 1. The Swedish total antibiotic sales (J01) for 2019-2022 and the target for 2030. DDD per 1000 inhabitants per day

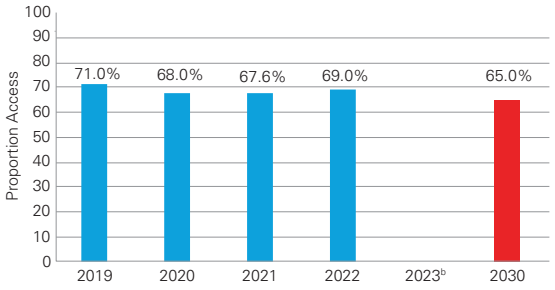


[a]No reported data due to confidentiality of sales data

Source: the Public Health Agency of Sweden

- Take appropriate national measures aimed at ensuring that, by 2030, at least 65% of the total consumption of antibiotics in humans belongs to the Access group of antibiotics as defined in the AWaRe classification of the WHO.

Figure 2. Proportion of antibiotics (J01)[a] in the Access group of the AWaRe classification in Sweden 2019-2023, according to ESAC-Net.

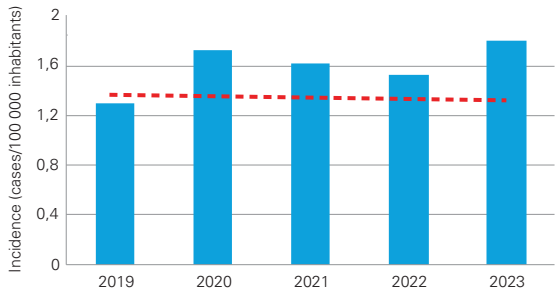


[a]Agents included in this analysis: antibacterials for systemic use, neomycin, streptomycin, polymyxin B, kanamycin, vancomycin, colistin, rifamixin, fidaxomicin, rifamycin, rifampicin, rifabutin, metronidazole, tinidazole, ornidazole and secnidazole.
[b]No reported data due to confidentiality of sales data

Source: the Public Health Agency of Sweden

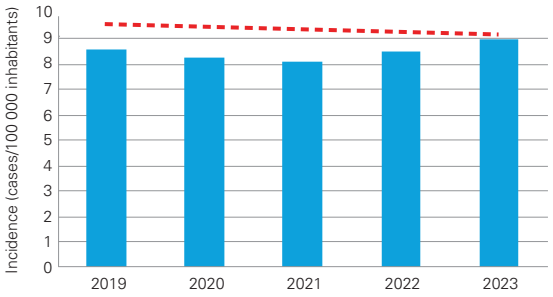
- Take appropriate national measures aimed at ensuring that, by 2030, the total incidence of bloodstream infections with methicillin-resistant *Staphylococcus aureus* (MRSA) (cases per 100 000 inhabitants) is reduced by 15% in the EU, compared to the baseline year 2019. The target for Sweden is a 3% reduction by 2030.

Figure 3. Cases with cefoxitin resistant *S. aureus* (MRSA) in blood during 2019 to 2023. The red line indicates the target for 2030.



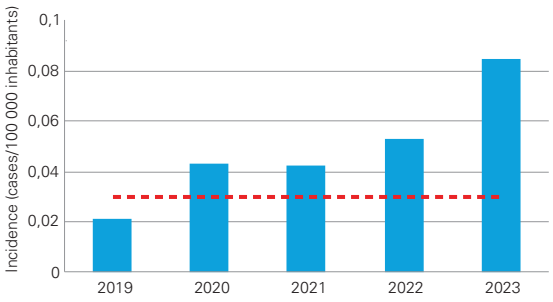
- Take appropriate national measures aimed at ensuring that, by 2030, the total incidence of bloodstream infections with third generation cephalosporins-resistant *Escherichia coli* (cases per 100 000 inhabitants) is reduced by 10% in the EU, compared to the baseline year 2019. The target for Sweden is a 10% reduction by 2030.

Figure 4. Cases with cefotaxime resistant *E. coli* (ESBL) in blood during 2019 to 2023. The red line indicates the target for 2030.



- Take appropriate national measures aimed at ensuring that, by 2030, the total incidence of bloodstream infections with carbapenem-resistant *Klebsiella pneumoniae* (cases per 100 000 inhabitants) is reduced by 5% in the EU, compared to the baseline year 2019. The target for Sweden for 2030 is to maintain the low baseline level from 2019.

Figure 5. Cases with carbapenem resistant *K. pneumoniae* in blood during 2019 to 2023.



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Sales of antibiotics for animals

Brief on data sources, methodology and confidentiality

In Sweden, all veterinary medicinal products are sold by pharmacies. All pharmacies are obliged to report all sales of medicinal and veterinary medicinal products to the eHealth Agency which maintains a database of sales from pharmacies to animal owners (prescriptions dispensed) and to veterinarians (requisition for use in practice).

For confidentiality reasons, sales of classes with less than three products on the market have been aggregated as "others" in Table 2.1.

The sales of veterinary medicinal products for mixing into feed used for aquaculture for food production are not included in the data referred to above, as such feed is traded from other countries. Data on prescriptions for fish are collected through a separate system, see Comments by animal species, Fish.

Further details on data sources and inclusion criteria are given in Materials and methods, sales of antibiotics.

Trends in animal populations

Changes in the numbers of animals may affect trends in statistics on sales of antibiotics. Compared to 2014, the number of pigs slaughtered in 2023 was approximately equal, while the number of broilers has increased by 22%. The number of dairy cows decreased by 14% during the same period. The number of horses was estimated to 355 500 in 2016. The number of dogs was estimated to 784 000 in 2012 and 881 000 in 2017.

Further details on animal numbers and data sources are found in the subchapter Demographics and denominator data in this report.

Completeness of data

Until 2009, pharmacies in Sweden were run by a state-owned co-operation (a monopoly). In July 2009, the Swedish pharmacy market was reregulated and today, there are many pharmacies competing on the market. A few of those have niched in veterinary medicinal products, and they are allowed to sell on distance to animal owners and to veterinarians.

At the time of the reregulation, the responsibility to collect sales data from pharmacies was transferred from the monopoly to a state-owned infrastructure company, and a few years later (2014) to the newly formed eHealth Agency. All pharmacies are obliged to report all sales of medicinal and veterinary medicinal products to the eHealth Agency, and are supervised by the Medical Products Agency.

Between 2010 and 2015, there were two different problems resulting in lack of completeness of data. Sales of products sold on special license were incomplete between 2011 and 2013 due to system change. In 2013, concerns were also raised about a more general lack of completeness in the sales reported by pharmacies. The overall lack of completeness was estimated by SVA in collaboration with Marketing authorization holders and was in the range of 5 to 10%. The problem persisted until 2015.

A lack of completeness was also identified for 2017-2021. The cause was identified and corrected. Consequently, data for that period have been updated as from Swedres-Svarm 2022. Furthermore, the difference between 2021 and 2022 was inexplicably large (-12%). A thorough search for yet undiscovered errors was undertaken but none was identified. No indication of a corresponding decrease in sales of non-antibiotic veterinary medicinal products could be identified. (For more information, see Swedres-Svarm 2022).

Overall sales

The total yearly sales of antibiotics for animals over the last decade are presented in Table 2.1. The potencies of different antibiotics are not equal and therefore, each class should be evaluated separately.

Of the overall sales expressed as kg active substance, around 90% are products formulated for treatment of individual animals (injectables, tablets, intramammaries etc) and around 10% for treatment of groups or flocks (premixes, oral powders, solutions for in-water medication). In 2023, the total reported sales from Swedish pharmacies of antibiotics authorised for veterinary use were 9 069 kg, of which 55% was benzylpenicillin. The corresponding figures for 2014 were 9 912 kg and 52%, respectively.

Since 2014, sales of all classes of antibiotics except aminoglycosides have decreased or are stable (Table 2.1). Compared to earlier years, sales of aminoglycosides increased notably in 2022 and 2023. This is explained by increased use of aminoglycosides for treatment of post-weaning diarrhoea following the withdrawal of veterinary medicinal products with high levels of zinc oxide.

The proportion of sales of products on special license (in accordance with article 116 of Regulation (EU) 2019/6) of the total sales in kg active substance has increased from 4 to 6% in 2014-2018 to 14% in 2023 (Figure 2.1). The Swedish market for veterinary antibiotics is small, and for

Figure 2.1. Proportion (%) of sales on special license of total sales of antibiotics for animals (as kg active substance)

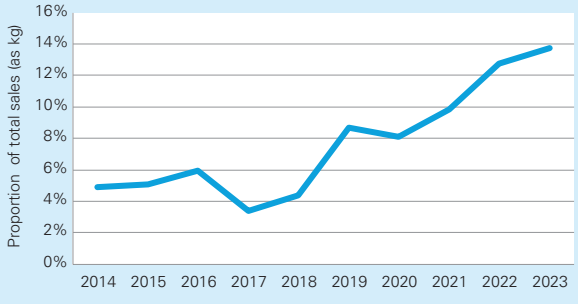


Table 2.1. Yearly sales of veterinary medicines with antibiotics, expressed as kg active substance per class[a].

ATCvet code	Class or subclass	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
QJ01AA, QG01A	Tetracyclines	787	685	515	529	516	524	638	748	573	661
QJ01CE,-R, QJ51	Benzylpenicillin[b]	5 148	5 479	5 620	5 591	5597	5 525	5 795	5 872	5 130	5 024
QJ01CA, QJ01CR	Aminopenicillins	635	642	677	638	670	643	759	664	612	652
QJ01D	Cephalosporins	299	267	242	210	187	161	163	164	150	114
QA07AA, QJ01G,-R, QJ51R	Aminoglycosides	300	322	312	302	376	343	404	366	506	661
QA07AB, QJ01E	Trimethoprim-sulphonamides	2 013	1 947	1 961	2 009	1 839	1 739	1 803	1 715	1 417	1 489
QJ01F	Macrolides & lincosamides	484	485	472	527	581	486	449	419	400	407
QJ01MA	Fluoroquinolones	45	34	30	25	30	21	28	22	16	16
QA07AA,QJ01BA, QJ01XQ	Others[c]	201	224	337	149	220	114	137	69	60	45
Total sales		**9 912**	**10 086**	**10 165**	**9 981**	**10 016**	**9 557**	**10 175**	**10 039**	**8 865**	**9 069**

[a]Data from 2011-2015 are uncertain because of a lack of completeness mainly affecting injectable products; [b]Also includes small amounts of phenoxymethylpenicillin and penicillinase stable penicillins; [c]Others: amphenicols, pleuromutilins and polymyxins.

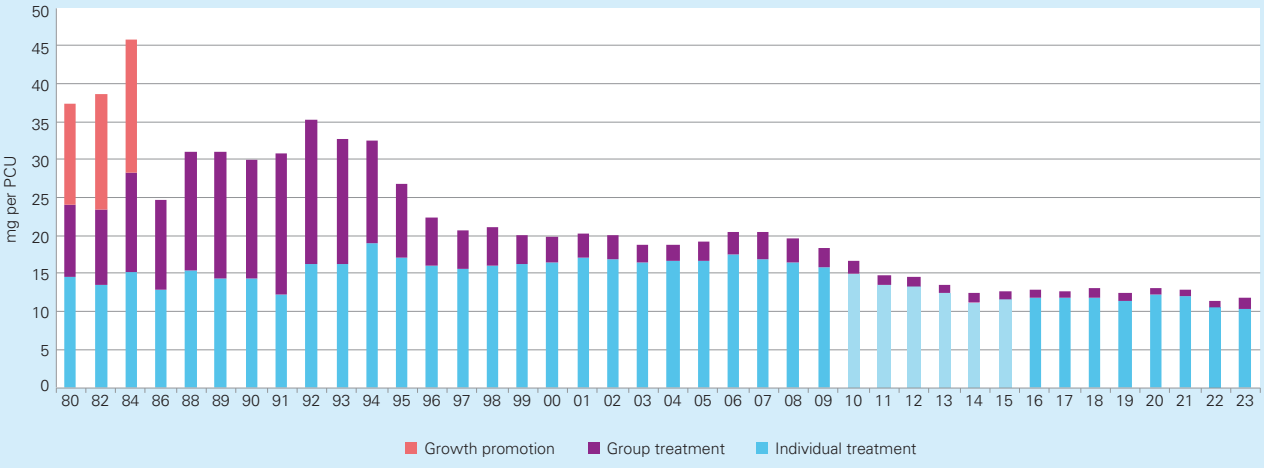
some therapy areas there are no suitable products authorised nationally. An example of that is products for treatment of post-weaning diarrhoea via water, where today products with aminoglycosides from other countries are sold on special license. Furthermore, for some substance-formulation types there are only one or two products with general marketing authorisation. When there are shortages of such products on the Swedish market, sales of similar products on special license are used to supplement. One example is that the two nationally authorised injectable products with trimethoprim-sulphonamides have not been available on the market since 2019.

Population corrected data

To correct for changes in the numbers of animals over time, the population correction unit (PCU) described in a publication from the European Medicines Agency was applied (EMA, 2011). The PCU is a purely technical term representing an approximation of the summed live weight of the major animal populations, excluding companion animals. In Figure 2.2, the total sales of antimicrobials for animals (including sales for companion animals) from 1980 and onward are presented as mg active substance per PCU, using figures for 2022 as a proxy for PCU in 2023. As sales for use in aquaculture are not included in the data presented, fish have been excluded from the PCU given in the reports from the ESVAC. Another difference from data published in the ESVAC-reports is that in Figure 2.2, data on products for use in companion animals are included.

Measured as mg per PCU, the overall sales were around 70% lower in 2023 compared to the average figures for 1980-1984 (i.e. before the Swedish ban on growth promoting antimicrobials in 1986). This is explained first by the removal of growth promoting antimicrobials in 1986, followed from the mid-90s by a major gradual decrease in the sales of veterinary products for medication via feed or water (group medication).

Figure 2.2. Yearly sales of antibiotics for animals expressed as mg per population correction unit (PCU)[a]. Uncertain figures are indicated with a lighter shade.



[a]Data from 2010-2015 are uncertain because of a lack of completeness mainly affecting injectable products. In the present figure, all products (including tablets) are included while in data presented in the European surveillance of veterinary antimicrobial consumption tablets are excluded when calculating mg/PCU.

A decrease in sales of products for individual medication was also noted in the past decade.

The Antimicrobial ad hoc expert group (AMEG) of the European medicines agency considers 3rd generation cephalosporins, fluoroquinolones and polymyxins as classes of antibiotics for which there should be special restrictions regarding their use in animals (category B, restrict) (EMA, 2019). Since 2014, the sales of these antibiotics, expressed as mg/PCU, have decreased considerably and have been below or much below 0.1 mg/PCU. For the 3rd generation cephalosporins and fluoroquinolones, the decrease is explained by a Swedish regulation that since 2013 limits veterinarians' rights to prescribe or use these types of antimicrobials (SJVFS 2023:21). As to polymyxins, the findings of transferable resistance to colistin were communicated to stakeholders during 2016 and onwards. An awareness among prescribers of the importance of this class of antimicrobials for public health, and of the potential consequences of transferable resistance, is a probable explanation for the observed decrease. Use of colistin has increasingly been replaced with use of antibiotics in other classes, e.g. aminoglycosides. From late 2023, veterinarians' right to prescribe polymyxins is also restricted by regulation SJVFS 2023:21.

Comment on data by animal species

Pigs

Antibiotics for pigs are predominantly sold on veterinary prescription by pharmacies to the animal owner, and information on species is recorded by the pharmacy. Sales reported by pharmacies as prescriptions for pigs are therefore believed to closely reflect sales in commercial herds.

In 2014 and 2023 the sales of antibiotics for pigs were 2 738 and 3 363 kg active substance, respectively, or 11,6 and 13,8 mg/kg slaughtered pig. The apparent increase is largely explained by an increased need to treat post-weaning diarrhoeas after the withdrawal of products with high levels of zinc oxide (formerly used for prevention, for more information see "In Focus Sales of antibiotics for group treatment of post-weaning diarrhoea in pigs".)

Of the total sales in kg active substance in 2023, around 70% were products for use in individual animals, and of those 65% were products containing benzylpenicillin.

Sales of fluoroquinolones for use in pigs were negligible, and no cephalosporins were sold for pigs in 2023. In Sweden, polymyxins (colistin) are only used for pigs. As noted under Population corrected overall sales, a marked decrease in sales has been noted since 2016 and sales are today most likely limited to cases where no alternatives are available.

Poultry

From 2011, the Swedish poultry meat association requests all treatments of broilers, parents, and grandparents to be reported as part of the Poultry health control programme. The programme covers more than 98% of the broilers reared in commercial production.

Antibiotics are rarely used for treatment of bacterial diseases in commercially reared *Gallus gallus*. Localised outbreaks can therefore have a major influence on the sales in a specific year. The reported figures are shown in Table 2.2. Over the last ten years, the yearly sales of fluoroquinolones for slaughter chickens and hens have been below or much below 0.25 kg. Cephalosporins or colistin are never used in broiler production in Sweden.

The nine flocks reported as treated were administered phenoxymethylpenicillin for necrotic enteritis. In addition, a limited number of individual male grand-parent birds were treated subcutaneously with injections with benzylpenicillin-dihydrostreptomycin.

Coccidiostats of the ionophore group are used as feed additives to control coccidiosis in the production of chickens for slaughter and for turkeys. Since the late 80s, narasin is by far the most widely used substance for broilers.

Table 2.2. Number of broiler flocks treated with antibiotics, and total number of flocks slaughtered per year.

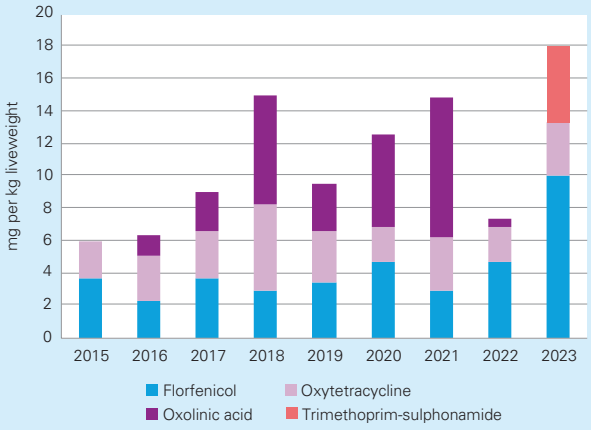
Year	Number of flocks produced	Number of flocks treated
2013	3 133	4
2014	3 138	4
2015	3 191	28
2016	3 300	14
2017	3 300	1
2018	3 223	4
2019	3 368	54
2020	3 557	11
2021	3 684	13
2022	3 470	10
2023	3 490	9

Fish

Medicated feed for fish is always traded from other Nordic countries. Therefore, the quantities sold are not captured by the national pharmacy sales collected by the eHealth Agency. Records of prescription of veterinary medicines for fish are collected annually by the veterinarian co-ordinating the limited number of veterinarians that deal with farmed fish and results are reported annually to the Board of Agriculture.

The occurrence of bacterial disease in farmed fish is influenced by water temperatures in summer, and the amounts prescribed may therefore vary between the years. Antibiotics prescribed in 2023 were products with florfenicol, oxytetracycline and trimethoprim-sulphonamide. Notably, no sales of products with oxolinic acid were reported in 2023.

Figure 2.3. Prescription of antibiotics for fish as mg per kg live weight of slaughtered fish.



In Figure 2.3, the prescription of antibiotics for fish is shown as mg per kg biomass produced (liveweight fish slaughtered). Florfenicol is primarily used for treatment of flavobacteriosis (*Flavobacterium psychrophilum*), a disease mainly affecting juveniles (with a very low weight). Oxolinic acid and oxytetracycline are used to treat diseases caused by *Aeromonas salmonicida* and *F. columnare*. These are diseases affecting production fish, i.e. of a higher weight. Therefore, the relations between the antibiotics shown in Figure 2.4 do not translate to treatment frequencies or actual exposure of individual fishes.

Horses

In 2023, sales of trimethoprim-sulphonamides formulated for oral use in horses (paste or powder) was 12% of the total sales, and 70% of the sales of all products with trimethoprim-sulphonamides. Since 2014, there has been a decrease in sales of trimethoprim-sulphonamides formulated for oral use in horses by 10%, measured as kg active substance. It is unclear if this decrease reflects increased adherence to guidelines or simply a decreasing number of horses, given that the latest population estimate is from 2016.

The sales of other antibiotics for horses cannot be estimated, as such products are frequently sold on requisition and administered by the veterinarian in connection with a clinical examination in ambulatory practice, in clinics, or in hospitals.

Dogs and cats

In 2023, the overall sales of veterinary medicinal products for oral medication of dogs were 521 kg compared to 880 kg in 2014. The corresponding figures for cats were 78 and 75 kg, respectively. As in previous years, aminopenicillins (with and without clavulanic acid), first generation cephalosporins and lincosamides were the classes with largest sales for dogs in 2023. For cats, products with aminopenicillins were by far the most sold (81%).

The figures above refer to sales of veterinary products only. Previously presented data on the total number of packages of antibiotics dispensed for oral use in dogs and cats, i.e. both veterinary antibiotics and those authorised for use in humans, have been revised resulting in minor differences compared to previously presented data.

The total number of packages dispensed for dogs were 132 167, and for cats 63 821. The corresponding figures for 2006 were 410 732 and 140 067, respectively.

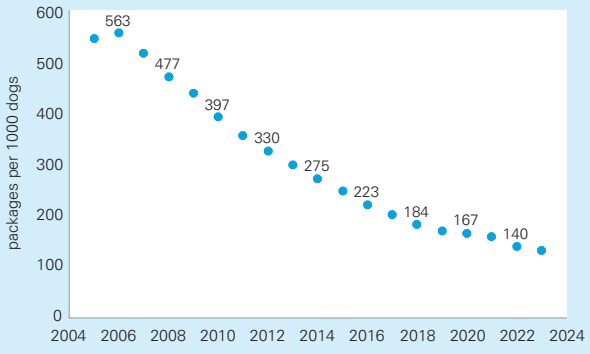
In 2006, sales for dogs corresponded to 563 packages per 1000 dogs. Since then, sales have decreased to 132 packages per 1000 dogs (-76%) (Figure 2.4). The latest estimate of number of dogs is from 2017, and population growth thereafter has been estimated based on rate of change since the previous estimate in 2012.

The most prominent changes relative to 2006 are noted for first generation cephalosporins (-90%), fluoroquinolones (-95%) and aminopenicillins with clavulanic acid (-88%).

As described in Svarm 2008, the emergence of infections with multiresistant methicillin-resistant *Staphylococcus pseudintermedius* and methicillin-resistant *S. aureus* triggered several national and local initiatives. This has most likely led to changes in prescribers' behaviour, which in turn explains the downward trends in sales of antibiotics for dogs shown in Figure 2.4.

The estimated numbers of cats are old and uncertain, and no calculations to correct for population size were made.

Figure 2.4. Sales of antibiotics for oral medication of dogs expressed as packages per 1 000 dogs. Data include antibiotics authorised for veterinary use as well as antibiotics for human use.



Sales of antibiotics for group treatment of post-weaning diarrhoea in pigs

Post-weaning diarrhoea is a multifactorial problem that occurs in piglets, usually within two weeks after separation from the sow. Factors such as changes in feed composition, stress, and mixing with pigs from other litters contribute to changes in the piglets' gut microbiota, lessening microbial diversity and leading to possible overgrowth of pathogenic *E. coli*. The resulting diarrhoea is potentially severe and affects the piglets' welfare and daily weight gain and may even lead to death if left untreated. To prevent post-weaning diarrhoea, and thus lessen the need for treatment with antibiotics, high doses of zinc oxide have long been added to pig feed. In June 2017, however, the European Commission issued an implementing decision stating that Member States must withdraw all marketing authorisations for veterinary medicinal products containing zinc oxide to be administered orally to food producing species no later than June 26, 2022 (Commission Implementing Decision of 26.6.2017; C(2017) 4529 final). Sweden opted for using the full phasing-out period, and during that time a collaborative group of stakeholders and representatives from relevant government agencies was formed to support the phasing out of high dose zinc oxide. Educational materials, such as texts, short films, podcasts and checklists, were developed and made available to all interested parties.

Since a potential consequence of the withdrawal of veterinary medicinal products with high doses of zinc oxide was an increased need to treat diarrhoeic weaners with antibiotics, the sales of relevant antibiotic products indicated for group treatment has been regularly monitored. Data on pharmacy sales for pigs of products containing colistin, neomycin, or paromomycin for oral group treatment, classified under ATCvet code QA07AA, were retrieved from the Swedish eHealth Agency.

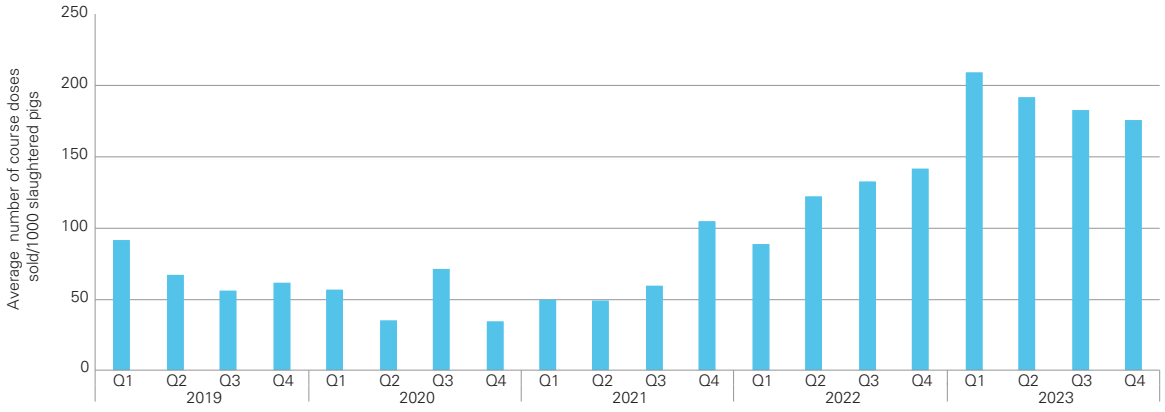
Course doses were calculated by multiplying the dosage indicated in the product information of each product by an assumed standard weight of 12 kg for weaner pigs and a treatment time of 3 days. Slaughter statistics for pigs were taken from the Swedish Board of Agriculture statistics database.

In order to calculate an approximate treatment incidence, an interval of five months was assumed between the treatment of a pig and slaughter. Thus, the number of course doses sold one month was divided by the number of pigs slaughtered five months later and the results were presented as the average number of course doses per 1000 pigs quarterly for 2019-2023 (Figure). When interpreting the data, it is important to note that actual use of the products may take place later than the sales.

There was an increase in sales in the fourth quarter of 2021, likely in anticipation of the withdrawal in June 2022, followed by an even more marked peak in the first quarter of 2023. This increase in sales is not matched by a corresponding decrease in sales of injectable products with sulphonamides and trimethoprim (data not shown). A downward sales trend was observed during the latter half of 2023, although pre-2022 levels have not been reached. No increase in neomycin resistance in *E. coli* from diarrhoeic pigs has been observed as yet (see Clinical isolates from animals, Pigs, Swedres-Svarm 2023).

Assessment of consumption is done regularly and data are discussed with stakeholder organisations. It is apparent that the need for group medication of post-weaning diarrhoea has increased during and after the phasing out of products with zinc oxide. The downward trend in 2023 may indicate that farm-specific preventive measures are increasingly implemented.

Figure. Quarterly (Q) sales of products for group medication of diarrhoea in weaner pigs (ATC-code QA07AA), expressed as course doses for pigs (12 kg, 3 days) divided by number of pigs slaughtered five months later.



The withdrawal of high dose zinc products occurred between the second and third quarters of 2022.

Antibiotic resistance in humans

Overview of surveillance systems and methods for antibiotic susceptibility testing

All surveillance of antibiotic resistance in Sweden relies on results from the clinical microbiology laboratories. The laboratories use the methods and breakpoints recommended by NordicAST for susceptibility testing. This Nordic organisation supports the implementation of EUCAST recommendations in the Nordic countries. National resistance surveillance is based on data from different sources and collections (Table 3.1).

Table 3.1. Summary of species and types of resistance included in national surveillance of antibiotic resistance.

Species, group or type	Sampling
Mandatory reporting (SmiNet)	
Enterobacterales with ESBL Enterobacterales with ESBL$_{CARBA}$ *Staphylococcus aureus* resistant to methicillin *Streptococcus pneumoniae* with reduced susceptibility to penicillin G *Enterococcus faecium* or *Enterococcus faecalis* resistant to vancomycin *Mycobacterium tuberculosis*[a] *Neisseria gonorrhoeae*[a]	Samples of all types for clinical, screening or case finding purposes.
Neisseria meningitidis[a]	Invasive disease (blood, CSF, or other normally sterile sample).
Voluntary surveillance (Svebar)	
Escherichia coli	Clinical sampling from blood and urine.
Klebsiella pneumonia	Clinical sampling from blood and urine.
Staphylococcus aureus	Clinical sampling from blood and skin and soft tissue infections.
Streptococcus pneumoniae	Clinical sampling from blood.
Enterococcus faecalis *Enterococcus faecium*	Clinical sampling from blood.
Pseudomonas aeruginosa	Clinical sampling from blood and non respiratory infections.
Acinetobacter spp.	Clinical sampling from blood.
Haemophilus influenza	Clinical sampling from blood and nasopharynx.
Streptococcus pyogenes *Streptococcus agalacticae*	Clinical sampling from blood.
Clostridioides difficile[b]	Clinical sampling from faeces.
Salmonella spp[c]	Clinical sampling from blood, faeces and urine.
Campylobacter jejuni[c]	Clinical sampling from faeces.
Shigella spp[c]	Clinical sampling from faeces.
Microbiological characterisation programme	
Enterobacterales with ESBL$_{CARBA}$	All isolates from clinical, screening or case finding samples producing ESBL$_{CARBA}$.
Enterobacterales with resistance to cefiderocol, ceftazidim-avibactam, colistin, imipenem-relebactam and meropenem-vabrobactam	Isolates from clinical, screening or case finding samples.[d]
Acinetobacter spp. with ESBL$_{CARBA}$	All isolates from clinical, screening or case finding samples with reduced susceptibility to meropenem.
Acinetobacter spp. with resistance to cefiderocol	Isolates from clinical, screening or case finding samples.
Pseudomonas spp. with ESBL$_{CARBA}$	All isolates from clinical, screening or case finding samples producing ESBL$_{CARBA}$.
Pseudomonas spp. with resistance to cefiderocol	Isolates from clinical, screening or case finding samples.[d]
Staphylococcus aureus resistant to methicillin	All isolates from clinical samples.
Streptococcus pneumoniae with reduced susceptible to penicillin G (MIC ≥ 0.5)	All isolates from clinical, screening or case finding samples.
Enterococcus faecium or *Enterococcus* faecalis resistant to vancomycin or linezolid	All isolates from clinical, screening or case finding samples.
Clostridioides difficile	All isolates from clinical samples during weeks 39-40.
Haemophilus influenzae with cephalosporin resistance	All isolates from clinical, screening or case finding samples.

[a]All infections with these bacteria are mandatory to report. Antibiotic resistance data are acquired from these surveillance programs. [b]A separate voluntary surveillance programme based on reports from laboratories. [c]All infections with these bacteria are mandatory to report. However, the antibiotic resistance data are acquired through voluntary reporting in Svebar. [d]With some exceptions, plese see www.folkhalsomyndigheten.se for details.

Indicators of antibiotic resistance

Since 2020, resistance to cefotaxime in *E. coli* isolated from blood and the proportion of MRSA among *S. aureus* isolated from blood, both from men and women separately, have been used as indicators for antibiotic resistance in Sweden. The results for these are presented under their respective section.

Notifiable diseases

Four types of antibiotic resistance in bacteria are included in the Swedish Communicable Diseases Act. These are *Staphylococcus aureus* resistant to methicillin (MRSA), *Streptococcus pneumoniae* with reduced susceptibility or resistance to penicillin (PNSP), *Enterococcus faecalis* and *Enterococcus faecium* resistant to vancomycin (*van*A or *van*B, VRE), and Enterobacterales with ESBL (including AmpC) or $ESBL_{CARBA}$. However, ESBL and $ESBL_{CARBA}$ are reported separately. As in previous years, the notifications of ESBL have greatly exceeded the other three (Figure 3.1 and Table 3.2).

Voluntary surveillance based on clinical samples

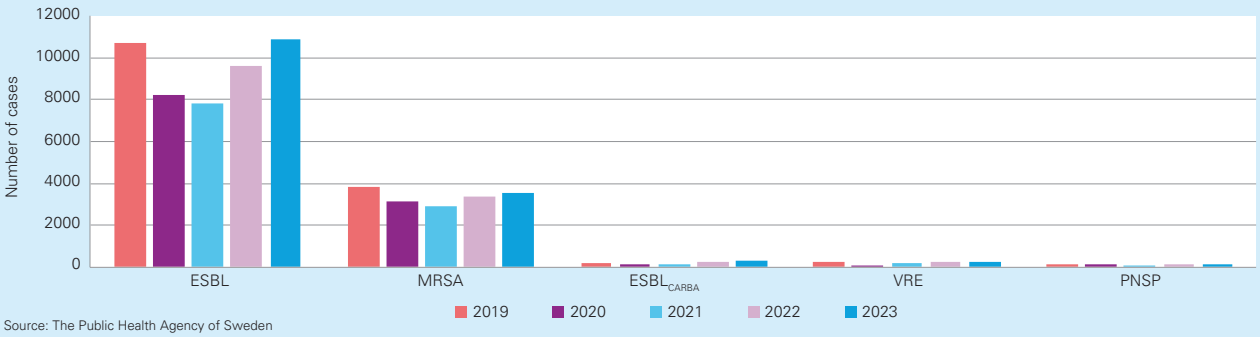
This surveillance uses results collected from the regional clinical microbiology laboratories. From 2015 and onwards, all data on clinical isolates from humans have been collected through Svebar. This is a system that automatically collects all culture results from participating clinical microbiology laboratories. Currently, 22 laboratories deliver data to Svebar (May 2024). It is not possible to deduplicate data from Svebar since personal identification is not included in the system. Consequently, duplicate findings from blood and other samples are included. Patients with highly resistant isolates tend to be sampled more frequently, which could overestimate the resistance levels in some cases (Table 3.3). Most antibiotic resistance levels presented in this report are based on non-selective susceptibility testing from at least five laboratories, thus avoiding bias from hierarchical testing and regional differences. When data presented are based on selective testing, this will be indicated in the graphs and tables. The number of AST isolates for each species and antibiotic combination is given in the attached file. The 95% confidence intervals are presented in figures showing resistance. The confidence intervals are given from 2015 and onwards.

Data from Svebar are used for reporting both to EARS-Net (an ECDC surveillance system) and to GLASS (a WHO surveillance system). Prior to 2015, ResNet, a national surveillance programme on antibiotic resistance, was used to collect data. From 2015 and onwards, these yearly data are based on SIR reported by the clinical microbiology laboratories to Svebar.

Microbiological characterisation program

The Public Health Agency of Sweden provides microbiological characterisation programs for verification and characte-

Figure 3.1. Number of mandatory reported cases during 2023.



Source: The Public Health Agency of Sweden

Table 3.2. Summary of results for mandatory reported antibiotic resistance 2023.

	ESBL	$ESBL_{CARBA}$	MRSA	PNSP	VRE
Number of cases (incidence)	10 895 (103)	314 (3.0)	3 547 (34)	152 (1.4)	260 (2.5)
Proportion clinical infection	73%	30%	54%	45%	10%
Gender	66% women	55% men	51% women	64% men	58% men
Median-age (range)	59 year (0-100+)	58 year (0-100+)	34 year (0-100+)	49 year (0-93)	74 year (4-98)
Proportion of domestic cases	No information	31% (8% no data)	61% (12% no data)	63% (25% no data)	57% (5% no data)
Short epidemiological information	Community and health-care	Hospital abroad	Community	Community	Hospital, domestic spread
Bloodstream infections	897 (656 new cases 2023, 241 cases known from previous years)	21	103 (79 new cases 2023, 24 cases known from previous years)	7	5

Table 3.3. Number of laboratories used for antibiotic resistance calculations among clinical cases during 2015-2023.

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of clinical microbiology laboratories	9	9	10	9	20	21	22	22	22
Coverage of population (%)	52	52	55	52	78	86	89	89	89

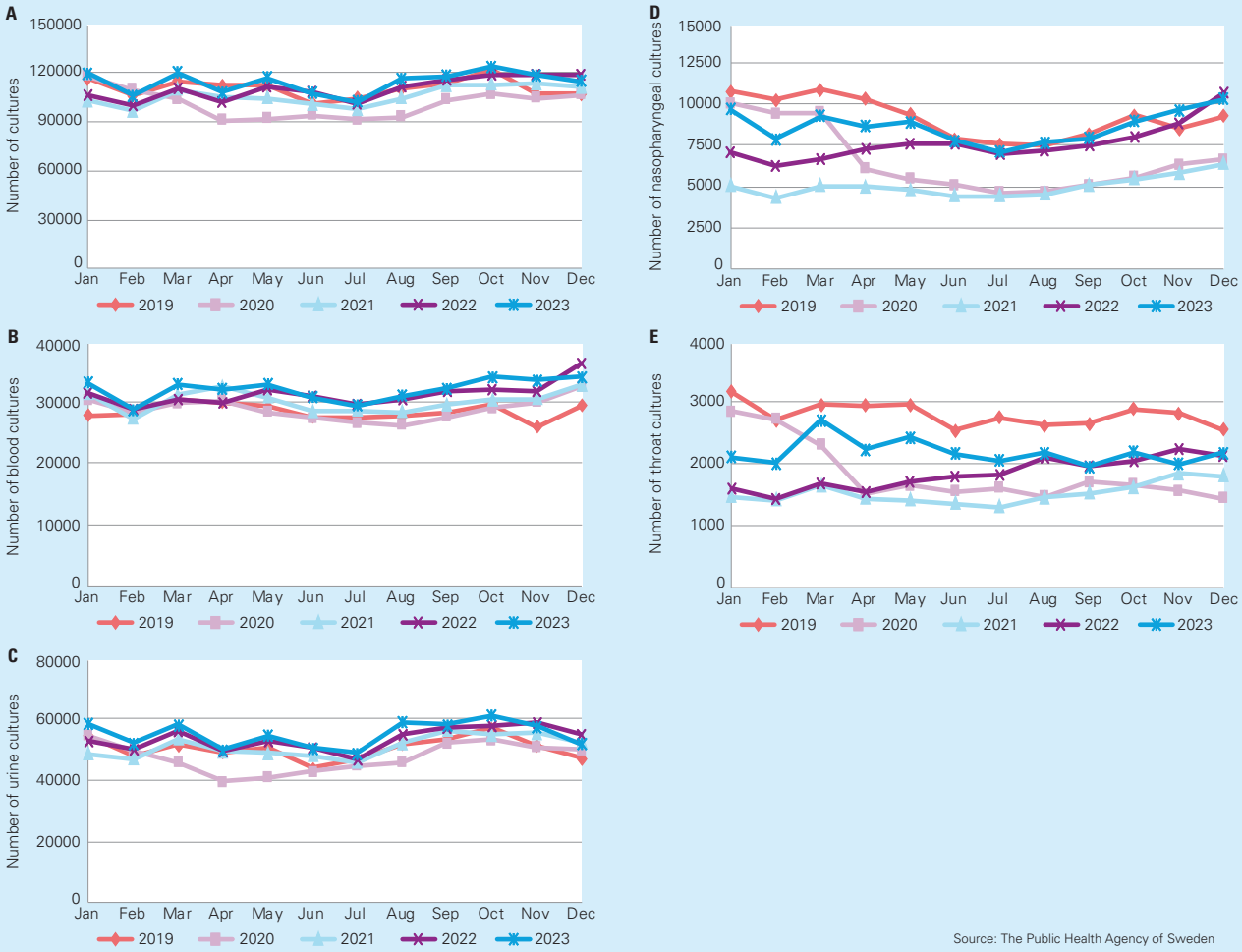
risation of isolates that participating laboratories send in. An overview is given in Table 3.1.

Overview of sampling and culture results

Denominator data is derived from Svebar. For the last five years, denominator data from twelve clinical laboratories covering around 60% of the population in Sweden were included. In Figure 3.2, the annual numbers of analyses are presented for: total number of cultures (A), blood cultures (B), urine cultures (C), nasopharyngeal cultures (D) and throat cultures (E). The total number of cultures increased by 4% compared to 2022, for blood cultures and urine cultures the increase was 3%. The numbers of these cultures are now at a higher level than in 2019. Although there was an increase in the number of nasopharyngeal cultures (13%) and throat cultures (19%), these are still fewer than in 2019.

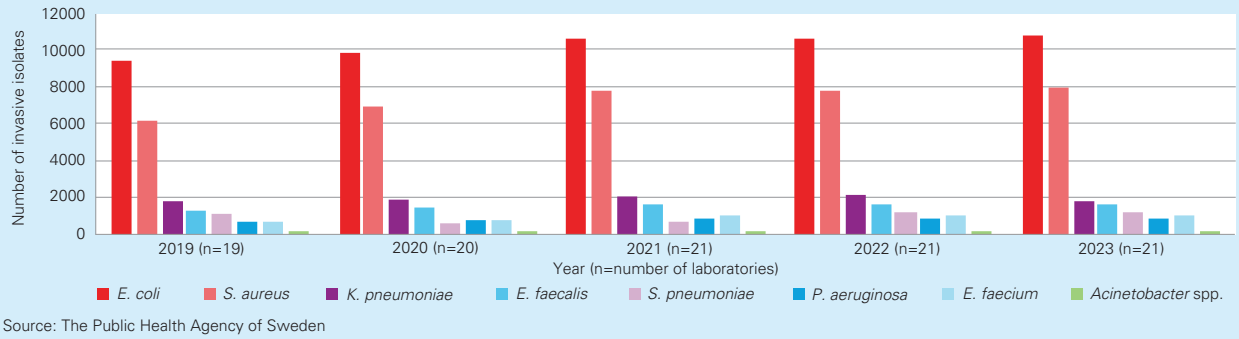
The number of bacteria reported to EARS-Net yearly is shown in Figure 3.3.

Figure 3.2 A to E. Number of analyses are presented for different and total number of cultures, year 2019-2023. Data from one laboratory is excluded in the calculation for number of all cultures and blood cultures due to a change in laboratory information system in 2021.



Source: The Public Health Agency of Sweden

Figure 3.3. Number of isolates, collected from blood during 2019-2023, reported to EARS-Net.



Source: The Public Health Agency of Sweden

Escherichia coli, Klebsiella pneumoniae, and other Enterobacterales with ESBL and ESBL$_{CARBA}$

Mandatory reporting of ESBL-producing Enterobacterales

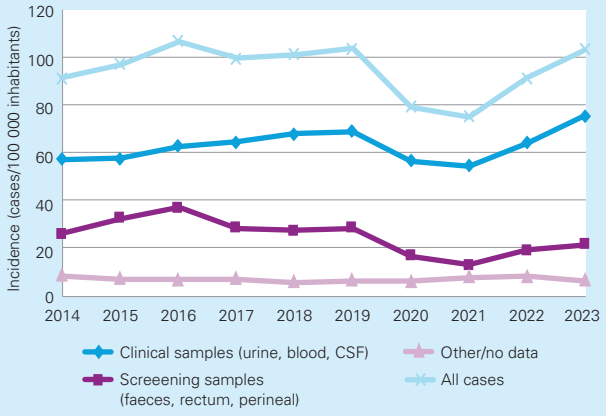
- Number of reported cases: 10 895 (previous year 9 611), relative change +13%.
- Number of bloodstream infections: 897 (previous year 818).

Trends

The ESBL incidence increased to 103 new cases per 100 000 inhabitants in 2023, see Figure 3.4. The increase was seen in clinical samples (urine, blood and cerebrospinal fluid (CSF)) and in samples taken for screening purposes (faeces, rectum and perineal). The number of bloodstream infections (BSI) with ESBL-producing Enterobacterales has increased steadily since it became notifiable and is now above prepandemic levels (Figure 3.5). *E. coli* was the most common cause of BSI at 75%, followed by *K. pneumoniae* at 16%.

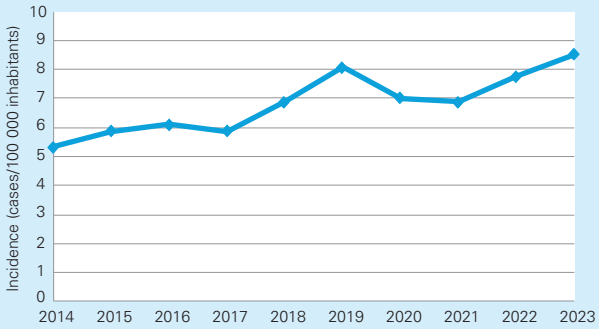
The gender and age distribution has not changed much since the surveillance started and reflects the expected occurrence of urinary tract infections in the different groups. The elderly, 85 years and older (n=1 134, incidence 402) had the highest incidence, followed by children under one year of age (n=340, incidence 338). The high incidence in neonates is probably a result of screening and contact tracing at neonatal units. Among the elderly, urinary tract infections are common bacterial infections explaining the high incidence in this group. As in previous years, the most commonly reported species was *E. coli*, found in 83% of all cases, followed by *K. pneumoniae* with 11%. The remaining cases comprised of several other species of Enterobacterales (for detailed information see attached file Figure 3.4).

Figure 3.4. The incidence (cases/100 000 inhabitants) of cases with ESBL-producing Enterobacterales in relation to type of infection, year 2014–2023.



Source: The Public Health Agency of Sweden

Figure 3.5. The incidence (cases/100 000 inhabitants) of invasive cases with ESBL-producing Enterobacterales, reported during year 2014–2023.



Source: The Public Health Agency of Sweden

Clusters and outbreaks

In 2023, 19 clusters or pairwise related cases (2–28 cases) of ESBL were detected based on whole genome sequencing and subsequent SNP-based analysis. The 19 clusters include six clusters that had one or more cases prior to 2023. Twelve clusters with ESBL-producing Enterobacterales were caused by *E. coli*, five by *K. pneumoniae* and two by *Klebsiella oxytoca*. Twelve of the clusters were healthcare-related and as many as eight of these were linked to neonatal wards. The largest cluster, with a total of 28 cases, is related to an outbreak of *K. oxytoca* with a CTX-M-15 gene. The first isolates arrived in 2022 and there was a sharp increase in spread in 2023. However, outbreaks with ESBL-producing Enterobacterales are not consistently reported.

Comments

In 2023, the number of cases with ESBL-producing Enterobacterales increased to prepandemic levels. The increase is probably linked to a rise in international travel.

Mandatory reporting of ESBL$_{CARBA}$-producing Enterobacterales

- Number of reported cases: 314 (previous year 240), relative change 31%
- Number of bloodstream infections: 21

Trends

In 2023, the incidence for ESBL$_{CARBA}$-producing Enterobacterales was 3.0 cases per 100 000 inhabitants, an increase with 31% compared to 2022. A majority, 65% of the cases, were carriers (Figure 3.6). Most cases reported as acquired abroad (62%, n=194) were identified in targeted screening (n=119) after healthcare abroad (n=78). Of the 96 domestic cases, 51 were identified by investigation of clinical infection. The proportion of domestic cases with healthcare-acquired ESBL$_{CARBA}$ remained mainly at the same level as previous year (35%, n=34). For 45 domestic cases, information of acqui-

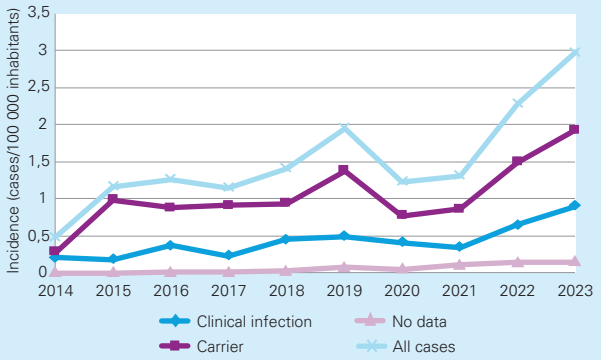
sition was missing. The median age was 58 and 55% of the cases were men. The most common countries of infection in the notifications were Sweden (n=96), Turkey (n=23), India (n=18) and Egypt (n=18).

Microbiological surveillance program, ESBL$_{CARBA}$-producing Enterobacterales

All ESBL$_{CARBA}$ isolates from notified cases in 2023 have been characterised using whole genome sequencing (WGS). The most common carbapenemase-producing Enterobacterales was *E. coli*, accounting for 61% of all cases, followed by *K. pneumoniae* (28%). Since 2021, a sharp increase is seen for the number of cases of clinical infection with carbapenemase-producing *E. coli*. Carriers with carbapenemase-producing *E. coli* and *K. pneumoniae* increased during the same time (Figure 3.7). Genes encoding for carbapenem resistance have also been detected in several other species of Enterobacterales. Multiple species, resistance genes and/or sequence types could be identified in several cases. The most abundant carbapenemase genes in these isolates were variants of NDM and OXA-48. In addition to these genes, KPC, VIM, IMP, IMI and GES were also detected, but to a lesser extent (Figure 3.8). The most frequent sequence types for *K. pneumoniae* were ST147, followed by ST395 and ST307. For *E. coli*, ST38 (OXA-48) was most abundant, followed by ST405 and ST648.

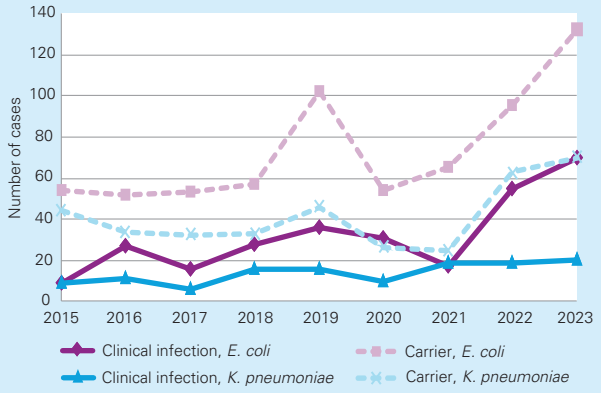
Apart from the genotypic analysis, isolates from notified cases in 2023 were tested for antibiotic susceptibility using broth microdilution (BMD) and disk diffusion. The phenotypic resistance shows a high degree of carbapenem resistance in metallo beta-lactamase (MBL)-producing isolates. However, in OXA-48-producing *E. coli*, meropenem and imipenem resistance is low. This contrasts with *K. pneumonia*, where meropenem and imipenem resistance is higher and about 50% of the isolates are sensitive. The high degree of resistance to the novel antibiotic cefiderocol is also notable, especially for NDM-producing isolates (Figure 3.9).

Figure 3.6. The incidence (cases/100 000 inhabitants) of cases with ESBL$_{CARBA}$ producing Enterobacterales in relation to type of infection, year 2014-2023.



Source: The Public Health Agency of Sweden

Figure 3.7. Number of cases with clinical infecrtion and carriers with carbapenemase-producing *E. coli* and *K. pneumoniae*, year 2015-2023.



Source: The Public Health Agency of Sweden

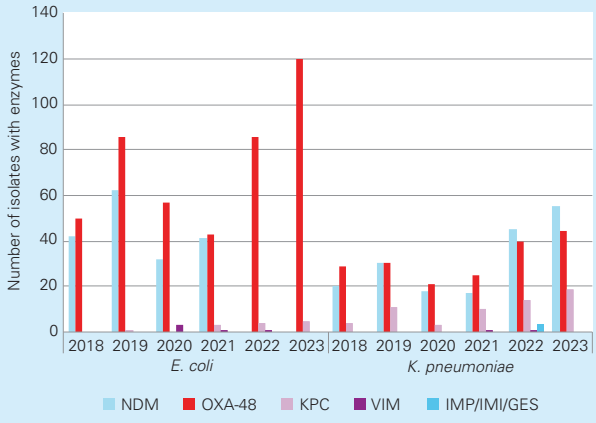
Clusters and outbreaks

Thirty-nine clusters or pairwise linked cases of ESBL$_{CARBA}$ were identified in 2023 (2-8 cases per cluster), confirmed by SNP analysis. Twenty-one clusters of ESBL$_{CARBA}$-producing Enterobacterales were caused by *E. coli*, 15 by *K. pneumoniae*, two by *Citrobacter freundii* and one each by *K. variicola* and *Proteus mirabilis*. Of the 39 clusters, 19 clusters had at least one case prior to 2023. For 16 of the 39 clusters, one or more of the cases were reported as a healthcare-related infection within Sweden in 2023. *K. pneumoniae* ST147 occurred in six of the clusters, while *E. coli* ST648 was observed in three.

Comments

Increased travel abroad has contributed to the increase in ESBL$_{CARBA}$ in 2023, but there were also more domestic cases. The lack of information on route of acquisition for nearly 50% of the domestic cases is worrisome. However, clusters can still be detected in the national surveillance program.

Figure 3.8. Number of isolates and enzyme types of ESBL$_{CARBA}$ in Enterobacterales in Sweden 2018-2023.



Source: The Public Health Agency of Sweden

Figure 3.9 A to D. Proportion of isolates with resistance from $ESBL_{CARBA}$ producing *E. coli* and *K. pneumoniae* collected among notified cases in 2022 (green) and 2023 (purple), divided by $ESBL_{CARBA}$-enzyme (A = *E. coli* with blaNDM, B = *E. coli* with blaOXA-48-like, C = *K. pneumoniae* with blaNDM, D = *K. pneumoniae* with blaOXA-48-like). Isolates have been classified as resistant (R) according to EUCAST breakpoint table 14.0 (meropenem = indications other than meningitis, amikacin/gentamicin/tobramycin/fosfomycin = urinary tract infections (UTI), nitrofurantonin = uncomplicated UTI).

Source: The Public Health Agency of Sweden

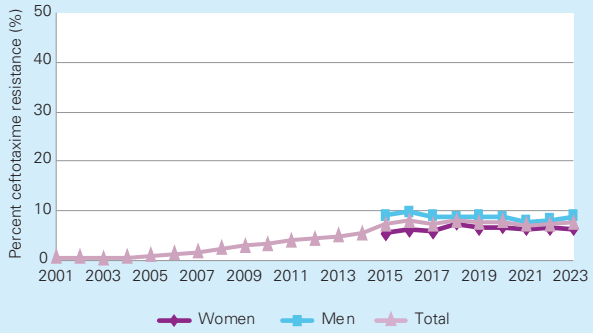
Escherichia coli, from blood and urine cultures

- Number of reported cases with $ESBL_{CARBA}$-producing *E. coli*: 211
- Number of reported cases with bloodstream infections caused by $ESBL_{CARBA}$-producing *E. coli*: 10
- Number of reported cases with ESBL-producing *E. coli*: 9 284
- Number of reported cases with bloodstream infections caused by ESBL-producing *E. coli*: 670

Trends

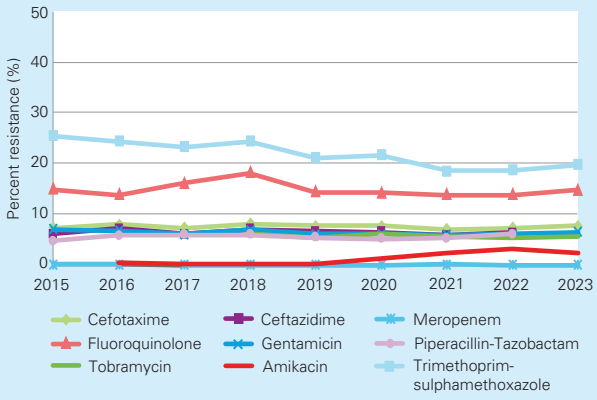
The proportion of ESBL-producing *E. coli* among invasive isolates, one of two AMR indicators, has increased continually over the years to 7.6% (Figure 3.10 and Figure 3.11). While the resistance to carbapenems remains very low, the proportion of resistance is higher among men in general. Combined resistance to cefotaxime/ceftazidime and gentamicin/tobramycin or the combination piperacillin-tazobactam and gentamicin/tobramycin was 2.6% and 1.6%, respectively (Table 3.4). The resistance levels remained stable among isolates from urine. Cefadroxil resistance, which can be used as an indicator for ESBL production, was 6.9% (Figure 3.12).

Figure 3.10. Antibiotic resistance indicator displaying resistance to cefotaxime in *E. coli* (ESBL) isolated from blood from women and men during 2001-2023.



Source: The Public Health Agency of Sweden

Figure 3.11. Antibiotic resistance in *E. coli* isolated from blood during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 5 183 to 10 629. The exact numbers are given in the attached file.



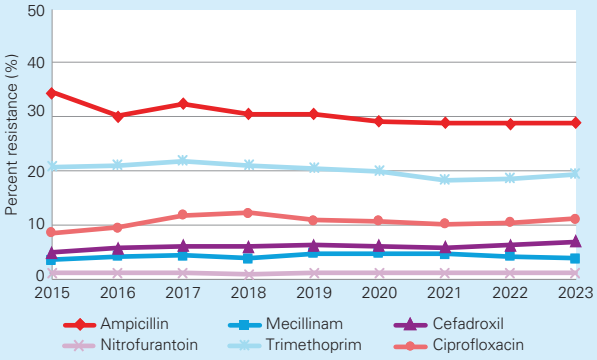
Source: The Public Health Agency of Sweden

Comments

For invasive isolates, resistance to piperacillin-tazobactam is presented based on the current breakpoints and historical data has been recalcutaled. Resistance to commonly prescribed oral antibiotics for treatment of urinary tract infections (UTI) caused by *E. coli* remained stable (Figure 3.11).

Resistance to ciprofloxacin is still high, and is now at approximately 15% and 11% for blood and urine isolates, respectively (Table 3.4, Figure 3.11 and Figure 3.12). The increasing ciprofloxacin resistance seen during 2016-2017 can mostly be explained by a change in the breakpoint for ciprofloxacin. The age and gender distributions among patients with *E. coli* isolated from urine reflects the expected occurrence of UTI in the different groups. The high level of ciprofloxacin resistance must be considered when choosing empirical treatment for febrile UTI, especially for men over 20 years of age (Figure 3.13).

Figure 3.12. Antibiotic resistance in *E. coli* isolates from urine during the years 2015-2023 The numbers of AST isolates for all years and antibiotics ranges from 103 223 to 227 259. The exact numbers are given in the attached file.



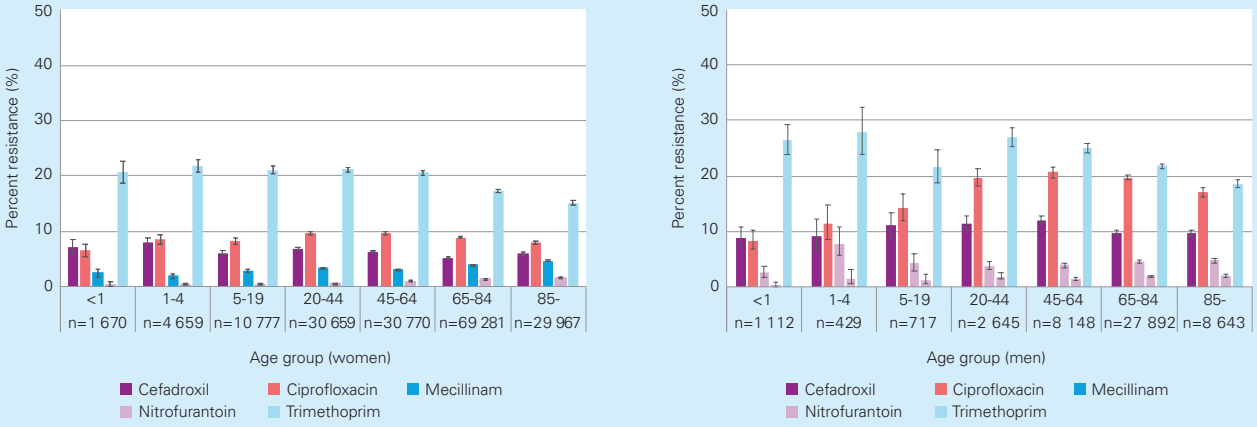
Source: The Public Health Agency of Sweden

Table 3.4. Proportion (%) of antibiotic resistant *E. coli* from blood or urine 2023. NA: Not Applicable.

Antibiotic	Blood isolates, % R (n=10 730)	Urine isolates, % R (n=227 259)
Ampicillin	NA	28.9
Cefadroxil	NA	6.9
Cefotaxime	7.6	NA
Ceftazidime	6.8	NA
Ciprofloxacin	14.7	11.2
Gentamicin	6.4	NA
Tobramycin	5.5	NA
Mecillinam	NA	3.8
Meropenem	0.0	NA
Nitrofurantoin	NA	1.2
Piperacillin-tazobactam	6.2[a]	NA
Trimethoprim	NA	19.3
Trimethoprim-sulphamethoxazole	19.7	NA
Combined resistance to Cefotaxime/ceftazidime + Gentamicin/tobramycin	2.6	NA
Combined resistance to both Piperacillin-tazobactam + Gentamicin/tobramycin	1.6	NA

[a]The resistance to piperacillin-tazobactam is presented based on the current breakpoints and historical data has been recalcutaled (NordicAST breakpoint table v 12.0).

Figure 3.13. Antibiotic resistance in *E. coli* from urine in women and men divided in age groups during 2023.



Source: The Public Health Agency of Sweden

Colistin resistance is occasionally seen in *E. coli* and is mainly tested in multiresistant isolates, most of which have a connection with healthcare abroad. It is important to determine colistin susceptibility with broth microdilution, as recommended by EUCAST.

Klebsiella pneumoniae, from blood and urine cultures

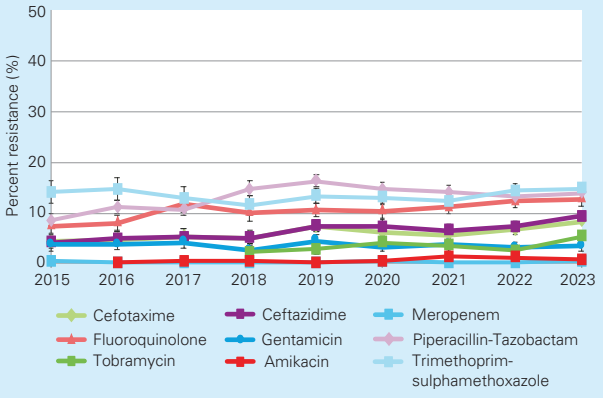
- Number of reported cases with $ESBL_{CARBA}$-producing *K. pneumoniae*: 96
- Number of reported cases with bloodstream infections caused by $ESBL_{CARBA}$-producing *K. pneumoniae*: 9
- Number of reported cases with ESBL-producing *K. pneumoniae*: 1 241
- Number of reported cases with bloodstream infections caused by ESBL-producing *K. pneumoniae*: 144

Comments

For invasive isolates, the resistance levels for all antibiotics tested increased, including for carbapenems where the resistance remains quite low. The resistance to piperacillin-tazobactam is presented based on the current breakpoints and historical data has been recalcutaled. The resistance to cefotaxime was 8.6% and the combined resistance to cefotaxime/ceftazidime and gentamicin/tobramycin or the combination piperacillin-tazobactam and gentamicin/tobramycin was 3.3% and 3.1%, respectively (Table 3.5 and Figure 3.14).

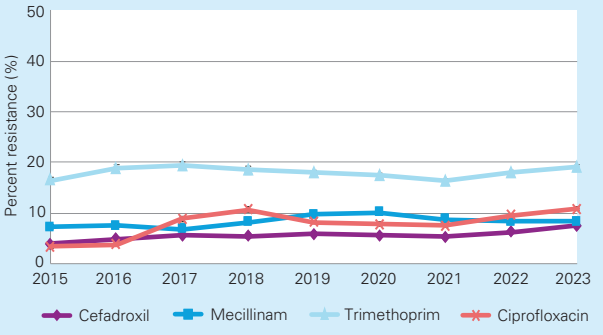
Resistance to commonly prescribed oral antibiotics for treatment of urinary tract infections caused by *K. pneumoniae* has remained relative stable during the last years (Figure 3.15). Cefadroxil resistance, which can be used as an indicator for ESBL production, was 7.5%. The high increase in ciprofloxacin resistance seen during 2016-2017 can mostly be explained by a change in the breakpoint for ciprofloxacin. As for *E. coli*, the high levels of resistance to ciprofloxacin must be taken into account when choosing empiric treatment for febrile UTI.

Figure 3.14. Antibiotic resistance in *K. pneumoniae* isolated from blood during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 973 to 2 161. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Figure 3.15. Antibiotic resistance in *K. pneumoniae* isolates from urine during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 9 901 to 25 243. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Colistin resistance is occasionally seen in *K. pneumonia* and is mainly tested in multiresistant isolates, most of which have a connection with healthcare abroad. It is important to determine colistin susceptibility with broth microdilution, as recommended by EUCAST.

Table 3.5. Proportion (%) of antibiotic resistant *K. pneumoniae* from blood or urine 2023. NA: Not Applicable.

Antibiotic	Blood isolates, % R (n=2 165)	Urine isolates, % R (n=25 243)
Cefadroxil	NA	7.5
Cefotaxime	8.3	NA
Ceftazidime	9.4	NA
Ciprofloxacin	12.7	10.9
Gentamicin	3.4	NA
Tobramycin	5.4	NA
Mecillinam	NA	8.3
Meropenem	0.5	NA
Piperacillin-tazobactam[a]	13.9	NA
Trimethoprim	NA	19.1
Trimethoprim-sulphamethoxazole	14.8	NA
Combined resistance to Cefotaxime/ceftazidime + Gentamicin/tobramycin	3.3	NA
Combined resistance to Piperacillin-tazobactam + Gentamicin/tobramycin	3.2	NA

[a]The resistance to piperacillin-tazobactam is presented based on the current breakpoints and historical data has been recalcutaled (NordicAST breakpoint table v 2.0).

Staphylococcus aureus including MRSA

Mandatory reporting of methicillin-resistant *Staphylococcus aureus*

- Number of reported cases: 3 547 (previous year 3 340), relative change +6%
- Number of bloodstream infections: 103 (previous year 96)

Trends

In 2023, the incidence of MRSA was 34 cases per 100 000 inhabitants, compared to 32 cases per 100 000 inhabitants in 2022 (Figure 3.16). The number of cases reported with clinical infections was 1 898 (54%), while 1 464 cases (41%) were listed as carriers.

There was almost equal distribution between women and men, with a median age of 34 for all cases. Among the domestic MRSA cases (n=2 164, 61%), children below one year of age (n=197, 196 cases/100 000 inhabitants) had the highest incidence, followed by the elderly, 85 years or older (n=180, 64 cases/100 000 inhabitants). The high incidence of MRSA among the young children is likely due to screening practices at neonatal- and maternal care units in combination with contact tracing around new cases.

Community-acquired infections continue to be the most prominent route of acquiring MRSA. Among MRSA cases acquired in Sweden, 27% (n=576) were reported as acquired from family/household contacts and 21% as community-acquired (n=448). The proportion of domestic cases with MRSA acquired in hospital as well as healthcare/care outside hospital was 6% and 8% respectively (n=125 and n=182), which is nearly the same as in 2020 to 2022. Little more than a third (n=797) of the domestic cases lacked information on acquisition.

Microbiological surveillance programme, MRSA

Epidemiological typing of MRSA has included *spa*-typing and analysis of PVL-status since 2006. Since January 2018, the national microbiological surveillance of MRSA only includes isolates from clinical cases. In addition to the surveillance program, typing data are obtained from regional microbiological laboratories. *Spa*-typing data were available for isolates from 1 414 (74%) of the clinical cases and from 696 (48%) sampled from asymptomatic carriers. Among clinical cases, the ten most prevalent *spa*-types were identified in 48% of the isolates. The six most prevalent *spa*-types in clinical isolates 2023 were t304, t008, t127, t223, t005 and t002 which all have remained the same since 2018, although the order of magnitude has varied.

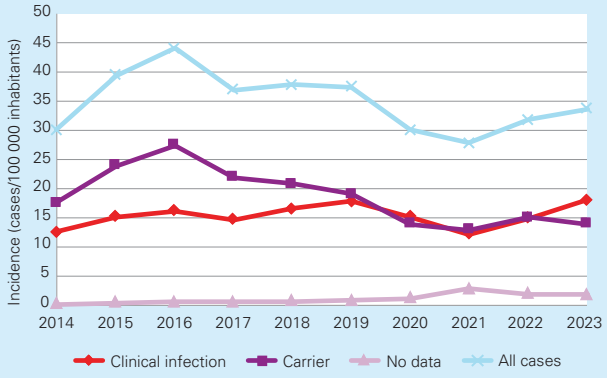
Clusters and outbreaks

In 2023, the Public Health Agency of Sweden performed whole-genome sequencing on 62 MRSA isolates in about twenty different investigations where spa-typing did not provide a sufficiently high resolution. From the comparisons, clusters or pairwise-linkages were found for 51 of the isolates sequenced, of which one was added to an investigation initially identified in 2019. The largest investigation included 24 of the isolates and originated from a neonatal care unit. For 11 of the sequenced isolates, no genetic linkage to another sequenced isolate was established.

Comments

The incidence of MRSA in Sweden increased in 2023 compared to 2022, but was still lower than the period before the pandemic.

Figure 3.16. The incidence (cases/100 000 inhabitants) of cases with MRSA in relation to type of infection, year 2014-2023.



Source: The Public Health Agency of Sweden

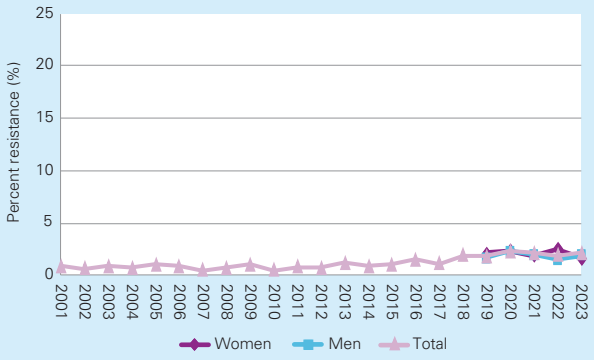
Staphylococcus aureus from blood and skin and soft tissue cultures

- Number of cases with MRSA reported: 3 547
- Number of cases with bloodstream infections caused by MRSA: 103
- The proportion of MRSA among *S. aureus* isolated from blood has increased to 2.1%, compared to 1.9% 2022.

Comments

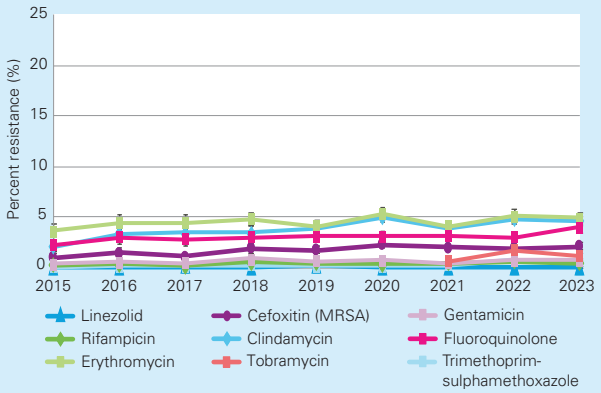
The proportion of MRSA in bloodstream infections, one of two AMR indicators, has slowly increased and is now 2.1% of isolated *S. aureus* (indicated by cefoxitin resistance). The proportion of resistance was 1.9% among men and 1.7% among women (Figure 3.17 and Figure 3.18). The proportion of MRSA in skin and soft tissue infections is 2.4% (Table 3.6 and Figure 3.19). Susceptibility testing to vancomycin is not routinely performed on cefoxitin-susceptible *S. aureus* and in 2023, 94 of 7 925 (1.1%) isolates from blood were tested for vancomycin resistance with no resistance detected.

Figure 3.17. One of the indicators for antibiotic resistance that shows the proportion of MRSA among *S. aureus* isolated from blood from women, men and in total.



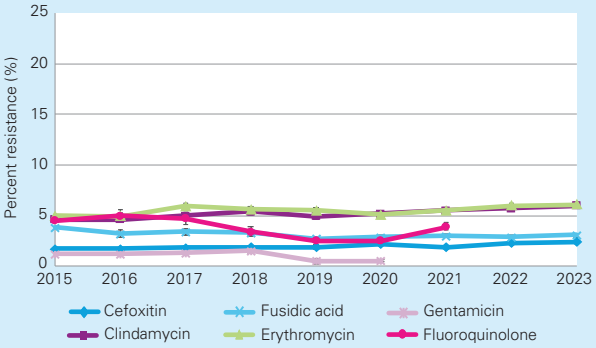
Source: The Public Health Agency of Sweden

Figure 3.18. Antibiotic resistance in *S. aureus* from blood during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 3 028 to 7 925. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Figure 3.19. Antibiotic resistance for *S. aureus* from skin and soft tissue samples 2015-2023. The resistance for norfloxacin is based on results from less than five laboratories in 2018-2020 and for gentamicin in 2020-2023. In 2023, data for aminoglycosides may be found in the attached file (not shown in graph) since the resistance rates are based on less than five laboratories. The numbers of AST isolates for all years and antibiotics ranges from 5 343 to 89 192. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Table 3.6. Proportion (%) of antibiotic resistant isolates in *S. aureus* from blood and skin and soft tissue infections 2023.

Antibiotic	Blood isolates, % R (n=7 919)	Skin and soft tissue % R (n=89 192)
Cefoxitin	2.1	2.4
Clindamycin	4.7	6.0
Erythromycin	4.9	6.1
Gentamicin	0.8	NA
Tobramycin	1.2	NA
Fluoroquinolone[a]	3.9	NA
Fusidic acid	NA	3.1
Linezolid	0.0	NA
Rifampicin	0.5	NA
Trimetoprim-sulphamethoxazole	0.2	NA

[a]Based on norfloxacin or ciprofloxacin.

Enterococcus faecalis and *Enterococcus faecium* including VRE

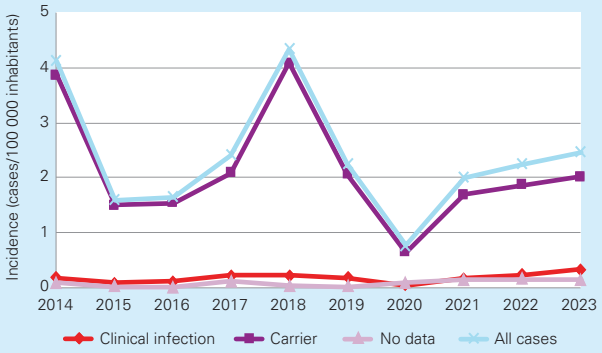
Mandatory reporting of vancomycin-resistant enterococci

- Total number of reported cases: 260 (previous year: 236), relative change +10%.
- Number of reported cases of *E. faecium* with vancomycin resistance: 250 (previous year: 227), relative change +10%
- Number of reported cases of *E. faecalis* with vancomycin resistance: 10 (previous year: 4)
- There were six cases infected with both *E. faecium* and *E. faecalis*.
- Number of bloodstream infections: 5 (previous year: 5)

Trends

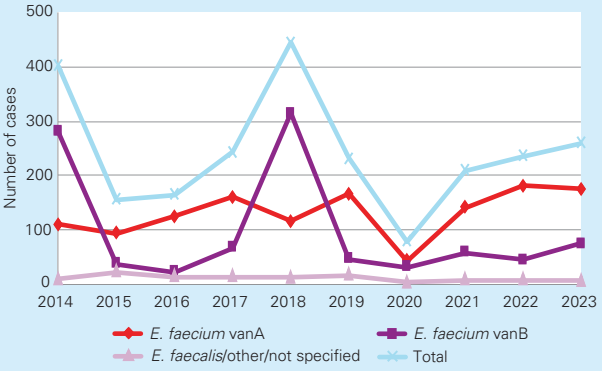
The national incidence of VRE increased from 2.2 to 2.5 cases per 100 000 inhabitants between 2022 and 2023. Seventeen of 21 regions reported cases of VRE during 2023. Of these cases, 154 (71%) were healthcare-related. A majority of the isolates (n=212, 82%) were from faeces, rectum and perineum and only 10% were from urine or wound (Figure 3.20). Five invasive VRE infections were reported in 2023. More than half of the cases were reported as acquired in Sweden (57%) and among the domestic cases, 38% were found through contact tracing and 46% through screening. Cases acquired abroad were mostly detected through screening (71%). The median age for VRE was 74 (range 4-98 years) and it is still most common among men (58%). In 2023, 250 *E. faecium* cases and 10 *E. faecalis* cases were reported. The *vanA* genotype was most commonly found (n=176) (Figure 3.21). In some cases, different genotypes of VRE were detected in the same patient. Therefore, a few more isolates than cases were epidemiologically typed.

Figure 3.20. The incidence (cases/100 000 inhabitants) of VRE in relation to type of infection, year 2014-2023.



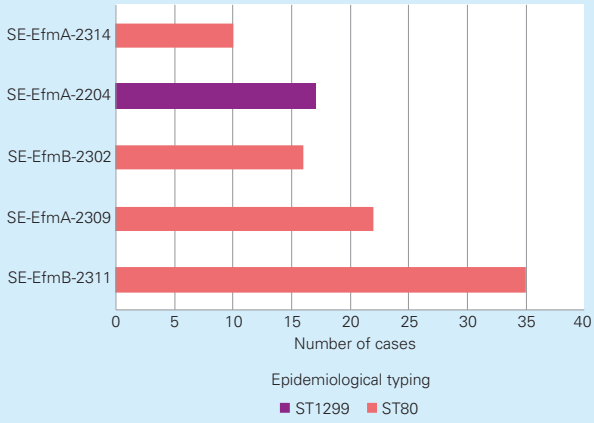
Source: The Public Health Agency of Sweden

Figure 3.21. Number of VRE cases and their corresponding van-type, year 2014-2023.



Source: The Public Health Agency of Sweden

Figure 3.22. Number of VRE cases within the five largest hospital-related outbreaks in 2023 and their respective sequence type.



Source: The Public Health Agency of Sweden

Microbiological surveillance programme, VRE

Whole genome sequencing (WGS) with "single nucleotide polymorphism" (SNP) based analysis and multilocus sequence typing (MLST) is used for epidemiological typing of VRE. The national VRE cluster nomenclature is as follows: species (Efm = *E. faecium*, Efs = *E. faecalis*) followed by *van*-gene (A or B), year of detection and a consecutive number for respective type found each year, e.g. SE-EfmB-2303. Isolates with no relation to other VRE isolates in the national database are denoted as unique (EfmA unique).

In 2023, five large hospital-related outbreaks with 10-35 cases each and twelve smaller clusters with 2-6 cases each were identified, all *E. faecium* (Figure 3.22). One of the large outbreaks denoted SE-EfmA-2204 was identified in April 2022 and still ongoing during 2023.

The five invasive cases were all caused by *E. faecium* carrying *vanA*. Two cases were caused by outbreak strains (SE-EfmA-2301, ST761 and SE-EfmA-2309, ST80). Genes and/or mutations connected to linezolid-resistance were detected in four isolates, one of which was from an invasive case.

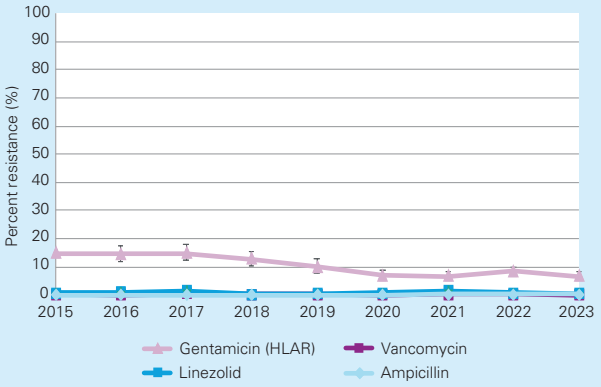
Comments

The number of VRE cases increased with 10% during 2023. This increase was mainly due to several hospitalrelated outbreaks. This stresses the importance of preventing spread of VRE in hospitals. Epidemiological typing of VRE is an important tool to monitor and investigate the spread of VRE. Culture and typing results are often necessary to initiate and motivate the extensive work needed to stop outbreaks of VRE.

Enterococcus faecalis and *Enterococcus faecium*, from blood cultures

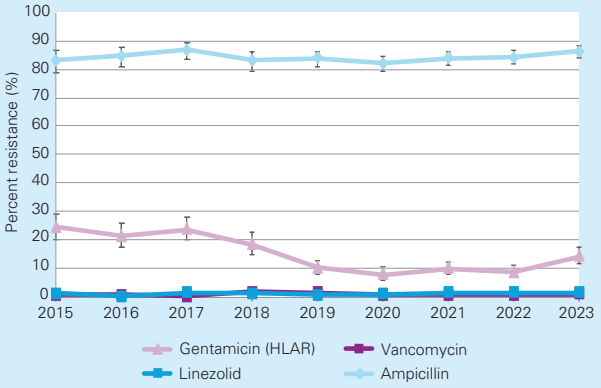
- Total number of reported cases: 260 (previous year: 236), relative change +10%.
- Number of reported cases of *E. faecium* with vancomycin resistance: 250 (previous year: 227), relative change +10%
- Number of reported cases of *E. faecalis* with vancomycin resistance: 10 (previous year: 4)
- There were six cases infected with both *E. faecium* and *E. faecalis*.
- Number of bloodstream infections: 5 (previous year: 5)

Figure 3.23. Antibiotic resistance in *E. faecalis* isolated from blood during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 704 to 1 605. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Figure 3.24. Antibiotic resistance in *E. faecium* isolated from blood during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 368 to 1 000. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Comments

The vancomycin resistance among invasive isolates remains low and was 0.7% for *E. faecium*. No vancomycin resistance was detected among *E. faecalis*. High-level aminoglycoside resistance (HLAR) has decreased compared to 2015 but an increase was seen in 2023 for *E. faecium* (Table 3.7 and Figures 3.23 and 3.24).

Table 3.7. Proportion (%) of antibiotic resistant *E. faecalis* and *E. faecium* isolated from blood 2023.

Antibiotic	Blood isolates *E. faecalis*, % R (n = 1 605)	Blood isolates *E. faecium*, % R (n = 1 000)
Ampicillin	0.1	86.2
Gentamicin (HLAR)	6.7	14.0
Linezolid	0.4	1.1
Vancomycin	0.0	0.7

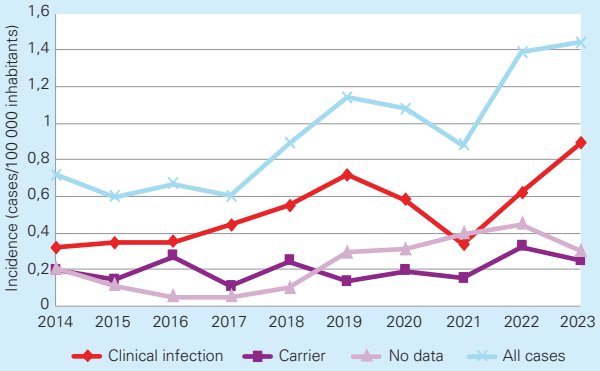
Streptococcus pneumoniae including PNSP

Mandatory reporting of *Streptococcus pneumoniae* with reduced susceptibility to penicillin (PNSP)

- Number of reported cases: 152 (previous year 146), relative change +4%
- Number of bloodstream infections: 7 (previous year 9)

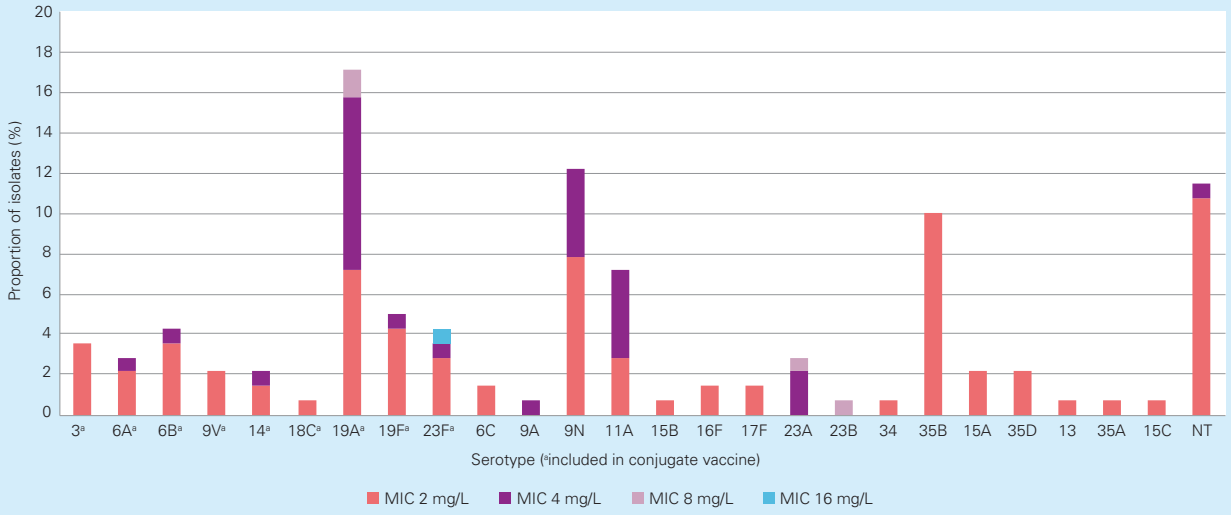
In November 2019, EUCAST posted a warning against the use of gradient tests for benzylpenicillin MIC in *S. pneumoniae*. Gradient tests were found to frequently underestimate MIC, especially around the R breakpoint (0.5 – 4 mg/L). Laboratories using gradient tests must be aware of this and MIC of 0.5 – 2 mg/L should be verified with broth microdilution. *S. pneumoniae* with a benzylpenicillin MIC over 1 mg/L are mandatory to report in Sweden.

Figure 3.25. The incidence (cases/100 000 inhabitants) of cases with PNSP in relation to type of infection, year 2014-2023.



Source: The Public Health Agency of Sweden

Figure 3.26. Distribution of serotype MICs among PNSP with PcG MIC > 1 mg/L (n=140).



Source: The Public Health Agency of Sweden

Trends

The national incidence of PNSP (MIC PcG> 1mg/L) remained at 1.4 cases per 100 000 inhabitants during 2023. The incidence for PNSP acquisition was highest among children under one year of age (7 cases per 100 000 inhabitants) and children aged 0-9 years old represented 23% (n=34) of all cases. Of all cases, 64% were men. PNSP was most often found in cultures from the nasopharynx (44%, n=67) and 52 isolates were found in sputum/ bronchoalveolar lavage (34%). Ninety-six cases were reported with clinical infections (62%, incidence 0.9) and 17% (n=26, incidence 0.2) as carriers (Figure 3.25). A majority of the cases had been acquired in Sweden (63%, n=96) and 12% of the cases were acquired abroad. For the remaining cases, no country of acquisition was given (35%).

Microbiological surveillance programme, *S. pneumoniae*

A total of 142 isolates with PcG MIC > 1 mg/L were sent to PHAS for serotyping during 2023 (93% of notified cases). Of these isolates, 39% (n=59) belonged to serotypes included in the conjugate vaccines (PCV10 and/or PCV15), Figure 3.26. The corresponding figures for 2022 and 2021 were 52% and 45%, respectively. Five of the seven isolates from invasive cases typed in 2023 were of vaccine type: 3 (n=1), 9V (n=1), 14 (n=2), 19A (n=1). The remaining two cases were of type 11A and 35B, i.e. not included in the vaccines.

To follow and evaluate the effect of vaccination against pneumococcal disease and to identify spread of antibiotic resistant clones, PHAS collects isolates of *S. pneumoniae* with PcG MIC ≥ 0.5 mg/L for serotyping. In 2023, 307 isolates were collected (including the 142 isolates from cases of PNSP). The serotype distribution was, in decending order: 19A (14%), NT (9%), 35B (8%), 11A (7%), 9N (6%), 23B (5%), 19F (5%), 23A (5%), and 15A, 15C, 3 6A (4%). Of the 307 isolates, 34% constituted of types included in the conjugate vaccines (PCV10 and/or PCV15).

Clusters and outbreaks

No clusters of PNSP were idientified in 2023.

Comments

The number of PNSP cases remained stable during 2023 compared to 2022. The number of invasive cases decreased to seven compared to nine cases last year. The increase from 2017 could partly be due to changes in diagnostics in incidence from 2017, as more laboratories have switched to reporting data based on broth microdilution.

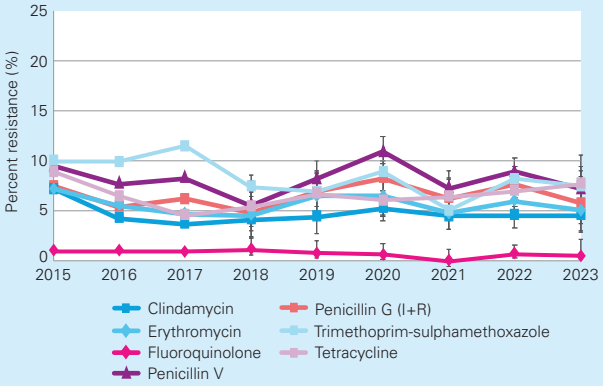
Streptococcus pneumoniae, from blood

- Number of reported cases: 152
- Number of bloodstream infections: 7
- Number of reported cases of invasive pneumococcal disease: 1 455

Comments

The methodological problem of underestimating benzylpenicillin (PcG) MIC when using gradient tests does not influence the resistance proportions, since I and R are reported together. Among invasive infections, the proportion of PcG non-susceptible isolates was 5.6% in 2023 (Figure 3.27).

Figure 3.27. Antibiotic resistance in *S. pneumoniae* isolated from blood during the years 2015-2023. Penicillin V resistance is based on susceptibility testing using oxacillin. The numbers of AST isolates for all years and antibiotics ranges from 550 to 1 182. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Haemophilus influenzae, from blood and nasopharynx cultures

- Number of reported cases of invasive *H. influenzae*: 225

Microbiological surveillance programme, *H. influenzae*

During 2023, 163 isolates were received within the microbiological characterisation program for cephalosporin resistance in *H. influenzae* at PHAS. The majority of these (n=150) showed high-level resistance to extended-spectrum cephalosporins, caused by alterations in penicillin-binding protein 3 (PBP3). Fifty of these isolates also carried the betalactamase *bla*TEM-1, which is the most prevalent gene of the acquired betalactamases. The remaining 13 isolates showed lower level resistance to cephalosporins.

Table 3.8. Proportion (%) of antibiotic resistant *H. influenzae* from blood or nasopharynx 2023.

Antibiotic	Blood isolates, % R (n = 213)	Nasopharynx isolates, % R (n =11 924)
Ampicillin/Amoxicillin	28.5	32.1
Cefotaxime	4.3	2.2
Fluoroquinolone[a]	1.4	1.6
Screen betalactam-resistance (PcG 1)	37.6	40.8
Tetracycline	1.9	0.4
Trimethoprim-sulphamethoxazole	25.4	29.3

[a]Nalidixic acid was used for detection of fluoroquinolone resistance.

Table 3.9. Antibiotic resistance in *H. influenzae* isolated from blood during the years 2016-2023. The numbers of AST isolates for all years and antibiotics ranges from 73 to 213. The exact numbers are given in the attached file.

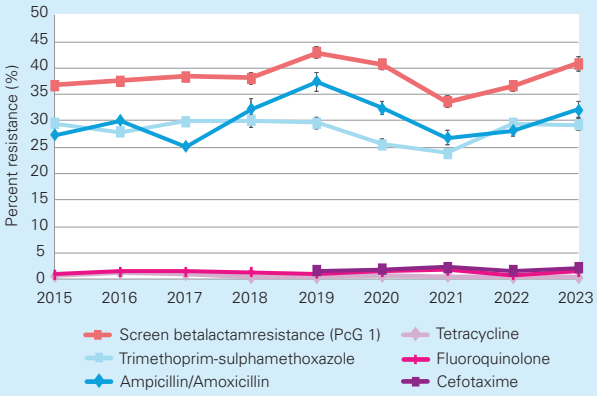
Species *Haemophilus influenzae*	2016			2017			2018			2019			2020			2021			2022			2023		
Sample: Blood	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**	**n**	**% R[a]**	**95% CI**
Number of AST isolates	**78**			**122**			**111**			**209**			**74**			**73**			**183**			**213**		
Screen betalactam-resistance (PcG 1)	78	33.3	(23.9-44.4)	120	26.7	(19.6-35.2)	111	36	(27.7-45.3)	208	34.1	(28.0-40.8)	60	50.0	(37.7-62.3)	67	26.9	(17.7-38.5)	164	32.3	(25.6-39.8)	178	37.6	(30.9-44.9)
Trimetoprim-sulphamethoxazole	78	21.8	(14.1-32.2)	121	14	(9.0-21.4)	111	12.6	(7.7-20.1)	209	23.9	(18.6-30.1)	74	12.2	(6.5-21.5)	72	13.9	(7.7-23.7)	183	21.3	(16.0-27.8)	213	25.4	(20.0-31.6)
Tetracycline	78	1.3	(0.2-6.9)	122	0.8	(0.1-4.5)	109	0.0	(0.0-3.4)	181	0.6	(0.1-3.1)	58	3.4	(1.0-11.7)	59	0.0	(0.0-6.1)	144	1.4	(0.4-4.9)	160	1.9	(0.6-5.4)
Ampicillin	56	26.8	(17.0-39.6)	40	20	(10.5-34.8)	34	29.4	(16.8-46.2)	157	34.4	(27.4-42.1)	64	43.8	(32.3-55.9)	55	25.5	(15.8-38.3)	142	28.2	(21.4-36.1)	158	28.5	(22.0-36.0)
Cefotaxime	69	0.0	(0.0-5.3)	103	1.0	(0.2-5.3)	90	2.2	(0.6-7.7)	178	2.8	(1.2-6.4)	67	3.0	(0.8-10.2)	53	1.9	(0.3-9.9)	159	3.1	(1.3-7.1)	187	4.3	(2.2-8.2)
Fluoroquinolone	55	1.8	(0.3-9.6)	89	1.1	(0.2-6.1)	75	0.0	(0.0-4.9)	160	0.0	(0.0-2.3)	44	2.3	(0.4-11.8)	73	5.5	(2.2-13.3)	134	0.7	(0.1-4.1)	148	1.4	(0.4-4.8)
Cefaclor	NA	NA	NA	NA	NA	NA	NA	NA	NA	98	30.6	(22.4-40.3)	35	28.6	(16.3-45.1)	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]From 2014 the resistance is expressed as % of isolates tested.

Comments

Invasive isolates of *H. influenzae* are notifiable according to the Communicable Disease Act regardless of antibiotic resistance. Cefotaxime resistance among invasive isolates remains low (Table 3.8 and Table 3.9). Among respiratory isolates, resistance levels are fluctuating a little but remain quite stable (Figure 3.28).

Figure 3.28. Antibiotic resistance in *H. influenzae* isolated from nasopharynx during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 2 460 to 13 332. The exact numbers are given in the attached file.

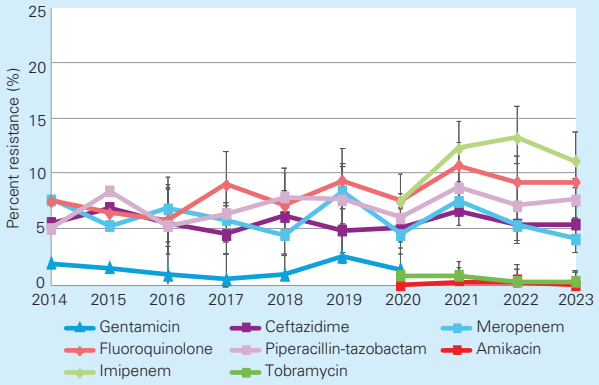


Source: The Public Health Agency of Sweden

Microbiological surveillance programme, *Pseudomonas* spp.

In total, 65 *Pseudomonas aeruginosa* isolates were received in 2023, of which twelve belonged to the microbiological surveillance programmes for $ESBL_{CARBA}$-producing *Pseudomonas* spp. Nine of these carried an NDM-gene, while three carried VIM. Two clusters were detected during 2023, with three (NDM-1, ST773) and two (VIM-1, ST111) patients, respectively.

Figure 3.29. Antibiotic resistance in *P. aeruginosa* isolated from blood during the years 2014-2023. The numbers of AST isolates for all years and antibiotics ranges from 348 to 857. The exact numbers are given in the attached file.



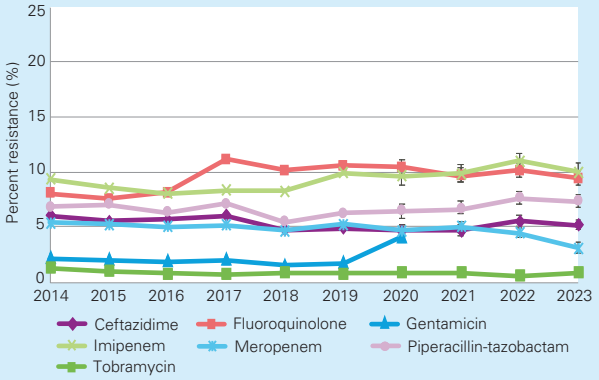
Source: The Public Health Agency of Sweden

Pseudomonas aeruginosa, from blood and non-respiratory cultures

Comments

Resistance to ceftazidime is most often due to efflux pumps and porin loss, not ESBL production. Resistance levels are stable for most antibiotics in both blood isolates and non-respiratory isolates (Table 3.10, Figure 3.29 and Figure 3.30). Tobramycin has replaced gentamicin as the recommended aminoglycoside. Colistin resistance is occasionally seen in *P. aeruginosa* and is mainly tested in multiresistant isolates, most of which have a connection with healthcare abroad. It is important to determine colistin susceptibility with broth microdilution, as recommended by EUCAST.

Figure 3.30. Antibiotic resistance in *P. aeruginosa* from non-respiratory isolates 2014-2023. Results from gentamicin are only available until 2020. The numbers of AST isolates for all years and antibiotics ranges from 1 980 to 18 832. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Table 3.10. Proportion (%) of antibiotic resistant *P. aeruginosa* isolated from blood and non-respiratory specimens 2023. NA: not applicable.

Antibiotic	Blood isolates, % R (n = 857)	Non-respiratory isolates, % R (n=17 552)
Ceftazidime	5.4	5.1
Ciprofloxacin	9.2	9.4
Tobramycin	0.2	0.8
Meropenem	4.1	3.0
Piperacillin-tazobactam	7.6	7.3

Acinetobacter spp., from blood cultures

Comments

During 2023, 160 isolates of *Acinetobacter* spp. from blood were reported to Svebar. The carbapenem resistance was 4.4% (Table 3.11). Since it is not possible to deduplicate data from Svebar, multiple isolates from the same patients are included in the data. During 2023, isolates with a multiresistant *Acinetobacter baumannii* from one patient was reported multiple times, resulting in unusually high resistance rates. If deduplicating would be performed, this would result in carbapenem resistance at 3.2% (95% CI 1.4-7.3) instead of the reported 5.6%. Bloodstream infections caused by *Acinetobacter* spp. are still rare in Sweden compared to other countries in Europe, where multiresistant *Acinetobacter* spp. is a problematic pathogen in hospitals. Colistin resistance is occasionally seen in *Acinetobacter* and is mainly tested in multiresistant isolates, most of which have a connection with healthcare abroad. It is important to determine colistin susceptibility with broth microdilution, as recommended by EUCAST.

Microbiological surveillance programme, *Acinetobacter* spp.

In total, 46 isolates were received in 2023 within the microbiological surveillance program for *Acinetobacter* spp. with reduced susceptibility to meropenem (I+R). This is similar to what was seen in 2020 (n=46) and 2021 (n=45), however, less than in 2022 (n=67). Of the 46 isolates 38 carried a species-specific OXA-genes (23, 24 or 58-like), five encoded an NDM gene, and in three, no carbapenemase was detected. Four clusters were active during 2023, including samples from two (OXA-23), four (OXA-23), five (OXA-24) and nine (OXA-23) patients.

Table 3.11. Antibiotic resistance in *Acinetobacter* species isolated from blood during year 2015-2023.

Species *Acinetobacter*	2015		2016		2017			2018			2019			2020			2021			2022			2023		
Sample: Blood	**n**	**% R**	**n**	**% R**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**
Number of AST isolates	**84**		**54**		**54**			**55**			**113**			**126**			**138**			**151**			**160**		
Meropenem	85	2.4	53	1.9	53	0.0	(0.0-6.8)	54	3.7	(1.0-12.5)	113	3.5	(0.9-7.5)	125	7.2	(3.8-13.1)	133	0.8	(0.1-4.1)	151	1.3	(1.8-8.4)	160	4.4	(2.1-8.7)
Ciprofloxacin	84	4.8	54	5.6	54	0.0	(0.0-6.6)	55	7.3	(2.9-17.3)	113	8.0	(4.2-14.4)	126	7.1	(3.8-13.0)	137	1.5	(0.4-5.2)	149	2.0	(0.7-5.8)	160	5.0	(2.6-9.6)
Trimethoprim-sulfamethoxazole	83	6.0	53	5.7	54	0.0	(0.0-6.6)	55	3.6	(1.0-12.3)	112	4.5	(1.9-10.0)	126	9.5	(5.5-15.9)	138	7.3	(4.0-12.8)	149	4.0	(1.9-8.5)	160	5.6	(3.0-10.3)
Gentamicin	66	3.0	43	7.0	51	0.0	(0.0-7.0)	49	6.1	(2.1-16.5)	72	6.9	(3.9-17.0)	90	11.1	(6.1-19.3)	111	5.4	(2.5-11.3)	94	2.3	(0.6-8.0)	87	1.1	(0.2-6.2)
Tobramycin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	67	0.0	(0.0-5.4)	65	12.3	(6.4-22.5)	75	2.7	(0.7-9.2)	79	1.3	(0.2-6.8)	95	5.3	(2.3-118.7)
Amikacin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65	7.7	(3.3-16.8)	61	11.5	(5.7-21.8)	66	1.5	(0.3-8.1)	78	3.8	(1.3-10.7)	62	6.5	(2.1-15.5)

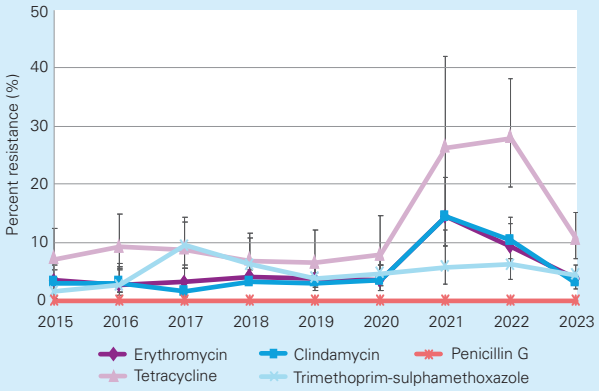
Streptococcus pyogenes, from blood cultures

- Number of reported cases of invasive *S. pyogenes*: 1 323

Comments

Invasive cases of *S. pyogenes* are notifiable according to the Communicable Disease Act and in 2023, 1 323 cases were reported. This is a large increase compared with the previous year (n=374) and the highest number of cases reported since it became notifiable in July 2004. AST results from 1 006 isolates were available from Svebar (Figure 3.31). Some laboratories did not test susceptibility to trimethoprim-sulphamethoxazole and tetracycline. The variation in resistance during 2021 should be interpreted with caution since there is a small number of tested isolates. Between the spring of 2020 and fall of 2022, resistance to clindamycin increased to levels above 10%. The increase was noted for all sample materials. In 2023, the resistance returned to prepandemic levels and is now 3%.

Figure 3.31. Antibiotic resistance in *S. pyogenes* (GAS) from bloodstream isolates during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 139 to 1 006. The exact numbers are given in the attached file.



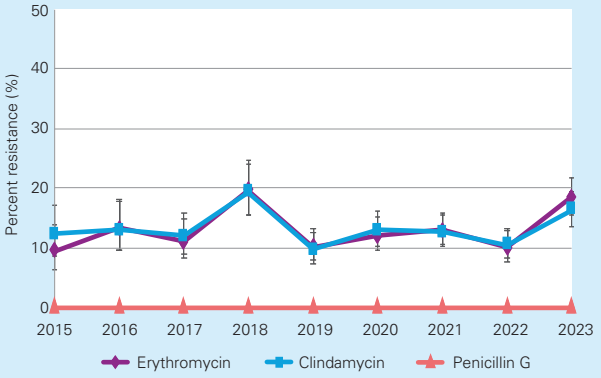
Source: The Public Health Agency of Sweden

Streptococcus agalactiae, from blood cultures

Comments

S. agalactiae is not included in the Communicable Disease Act. It is an important pathogen in the context of pregnancy and childbirth and can cause serious infections among others as well, mainly elderly with predisposing disease. Resistance to erythromycin and clindamycin is now 19% and 16%, respectively (Figure 3.32).

Figure 3.32. Antibiotic resistance in *S. agalactiae* (GBS) from bloodstream isolates during the years 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 184 to 607. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Shigella species

Mandatory reporting of *Shigella*

- Total number of reported cases: 728 (previous year: 434)
- Number of bloodstream infections: 0 (previous year: 1)

The increased number of reported *Shigella* cases during 2022 and 2023 are mainly due to an increase in number of cases infected abroad. In 2023, 72% of the cases were reported as acquired abroad and 19% reported as acquired in Sweden. The number of reported cases increased before 2020, partly explained by a shift in the microbiological method of detection used, where nucleic acid amplification tests are utilised more now.

In 2023, 78 cases with *Shigella* were also notified as ESBL-producing Enterobacterales. Of the 52 cases with known ESBL-type, 50 had $ESBL_A$ and two $ESBL_M$. No cases with *Shigella* carrying $ESBL_{CARBA}$ were reported during 2023.

Shigella spp., from faecal samples

In 2023, 201 isolates of Shigella in feacal samples were reported in Svebar and AST results were available for 195 isolates. The majority of isolates with AST were *S. sonnei* and *Shigella* species, with 48 % and 23% of the isolates, respectively. None of the isolates was carbapenem resistant (Table 3.12).

Comments

The number of isolates with an AST available for analysis was low. Hence, results should be interpreted with caution. The increase in cefotaxime resistance indicates a higher presence of ESBL among the tested isolates.

Table 3.12. Antibiotic resistance in *Shigella* spp. from faecal samples 2018-2023. The numbers of AST isolates for all years and antibiotics ranges from 40 to 242.

Species *Shigella* spp.	2018			2019			2020			2021			2022			2023		
Sample: Faeces	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**	**n**	**% R**	**95% CI**
Ciprofloxacin	174	25.3	(19.4-32.2)	242	14.5	(10.6-19.4)	63	22.2	(13.7-33.9)	65	21.5	(13.3-33.0)	151	23.2	(17.2-30.5)	195	33.8	(27.6-40.7)
Trimetoprim-sulphamethoxazole	179	80.4	(74.0-85.6)	240	71.7	(65.7-77.0)	63	73	(61.0-82.4)	65	69.2	(57.2-79.1)	152	73	(65.5-79.4)	195	74.4	(67.8-80.0)
Cefotaxime	173	25.4	(19.5-32.4)	235	19.1	(14.6-24.7)	62	11.3	(5.6-21.5)	64	32.8	(22.6-45.0)	151	33.8	(26.7-41.6)	194	36.1	(29.7-43.1)
Ceftazidime	173	3.5	(1.6-7.4)	234	3.4	(1.7-6.6)	61	3.3	(0.9-11.2)	64	6.2	(2.5-15.0)	151	7.9	(4.6-13.4)	192	7.8	(4.8-12.5)
Meropenem	145	0.0	(0.0-2.6)	204	0.0	(0.0-1.8)	55	0.0	(0.0-6.5)	51	0.0	(0.0-7.0)	140	0.0	(0.0-2.7)	188	0.0	(0.0-2.0)
Azithromycin	107	15	(9.4-22.9)	168	7.1	(4.1-12.1)	52	17.3	(9.4-29.7)	50	24.0	(14.3-37.4)	138	17.4	(12.0-24.6)	174	27.6	(21.5-34.7)
Piperacillin-tazobactam	102	0.0	(0.0-3.6)	152	0.0	(0.0-2.5)	40	2.5	(0.4-12.9)	44	0.0	(0.0-8.0)	123	1.6	(0.4-5.7)	145	0.7	(0.1-3.8)

Mycobacterium tuberculosis, mandatory reporting

During 2023, a total of 362 cases of tuberculosis (TB) were reported compared to 386 cases during 2022, a marginal decrease of 6%. Of the 362 cases, six were already on TB treatment when arriving in Sweden.

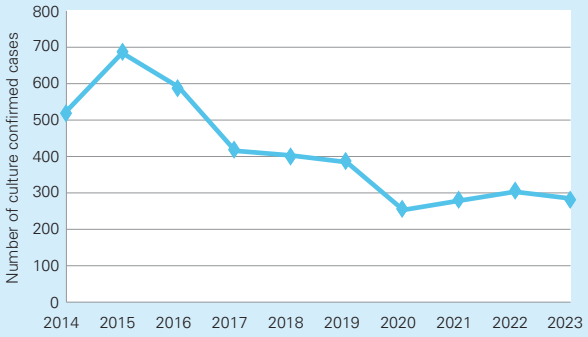
The number and proportion of culture-confirmed cases was 285 (80%) compared to 318 (82%) in 2022. *Mycobacterium bovis* was identified in one case, *Mycobacterium africanum* in one case and *Mycobacterium tuberculosis* in 283 cases (Figure 3.33). The proportions of *M. tuberculosis* cases diagnosed as MDR-TB was 2.5% (7/283) compared to 4.9% (15/307) in 2022. One of the MDR-cases was classified as pre-XDR-TB (additional resistance to fluoroquinolones).

Isolates of *M. tuberculosis* resistant to at least one of the four first line drugs (isoniazid, rifampicin, ethambutol or pyrazinamid) were identified in 35 patients, corresponding to 12.4% of the 283 patients with culture confirmed *M. tuberculosis* (Figure 3.34). As always, the most common resistance found was against isoniazid.

Of 53 cases with *M. tuberculosis* born in Sweden, 42 with culture confirmed diagnosis, two had isoniazid resistant TB and one had MDR-TB. Of all the TB cases reported in Sweden 2023, 85 % were born in another country. In total, 241 in this group had a culture confirmed infection with *M. tuberculosis* and 35 (15 %) had some kind of resistance, of which six had MDR-TB.

Genetic typing of TB isolates has been performed in Sweden since the late 1990's. This is done to identify clusters of cases as clustering indicates possible recent transmission and helps to identify missed opportunities of infection control. Of all the cases, 21% (75/362) were reported as infected in Sweden and of the 282 (including *M. bovis*) cases analysed with whole genome sequencing, 77% were unique isolates not belonging to any cluster.

Figure 3.33. The number of culture confirmed *M. tuberculosis* in Sweden cases in Sweden 2014-2023.

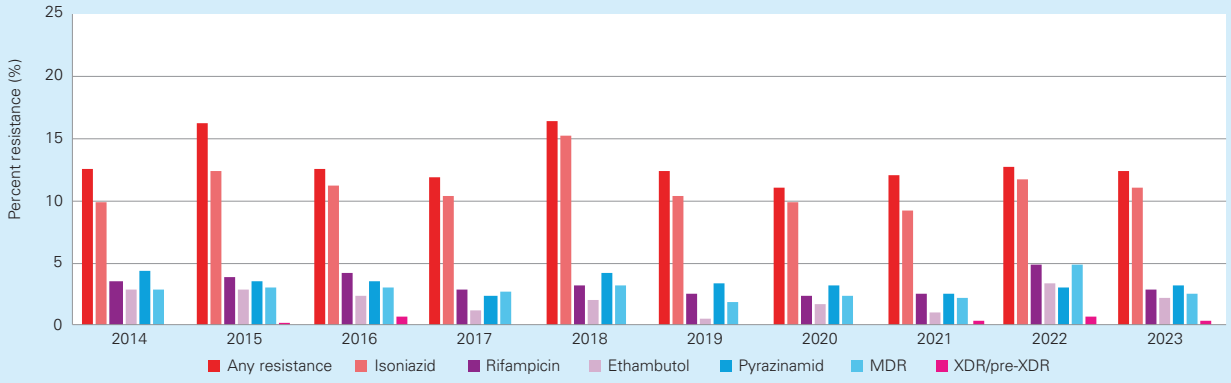


Source: The Public Health Agency of Sweden

The number of reported cases of TB increased slightly during 2021 and 2022 after the sharp decrease during 2020, attributed to the covid-19 pandemic. In 2023, the number of reported cases decreased slightly again.

In 2023, the number of MDR-TB cases decreased by 50% (from 15 to seven) compared to 2022, when there was a sharp increase. This was partly due to the war in the Ukraine, a country with a high percentage of their TB cases being MDR-TB (Figure 3.34).

Figure 3.34. Drug resistance in culture confirmed *M. tuberculosis* in Sweden 2014-2023.



Source: The Public Health Agency of Sweden

Neisseria gonorrhoeae, mandatory reporting

Gonorrhoea is a notifiable infection and in 2023, 4 212 cases (40 cases per 100 000 inhabitants) of gonococcal infections were reported to the Public Health Agency of Sweden. This represents an increase of 26% compared to 2022 (3 356 cases, 32 cases per 100 000 inhabitants). As in earlier years, most of the gonorrhoea cases in 2023 were identified in the three largest counties of Sweden, which comprise the cities Stockholm, Göteborg, and Malmö, respectively. Clinical isolates are in the present report described from the National Reference Laboratory for Sexually Transmitted Infections (an external body of the Public Health Agency of Sweden), Department of Laboratory Medicine, Clinical Microbiology, Örebro University Hospital, Örebro; Department of Clinical Microbiology, Karolinska University Hospital, Huddinge;

Table 3.13. Proportion (%) of antibiotic resistant clinical *Neisseria gonorrhoeae* isolates 2014-2023.

Antibiotic	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of AST isolates	**(n=384)**	**(n=462)**	**(n=601)**	**(n=528)**	**(n=580)**	**(n=1 035)**	**(n=1 713)**	**(n=1 583)**	**(n=894)**	**(n=2 448[a])**
Ceftriaxone	<1 (0.3)	0	0	0	0	0	0	0	<1 (0.1)	<1 (0.1)
Cefixime	2	2	1	<1 (0.6)	1 (1.2)	<1 (0.8)	2	<1 (0.5)	1	<1 (0.4)
Azithromycin	9	10	3	5	5b	12[b]	19[b]	25[b]	30[b]	33[b]
Ciprofloxacin	60	53	53	47	57	60	58	69	64	65
Spectinomycin	0	0	0	0	0	0	0	0	0	0

[a]For cefixime and spectinomycin, 2 248 *N. gonorrhoeae* isolates. [b]Using EUCAST ECOFF of 1 mg/L to distinguish isolates with azithromycin resistance mechanisms.

and Clinical Microbiology, Infection Prevention and Control, Office for Medical Services, Lund, Sweden. In 2023, 2 448 clinical *Neisseria gonorrhoeae* isolates (one per infection episode) are presented in regard to antimicrobial susceptibility.

Antimicrobial susceptibility testing was performed according to standardised and quality assured methodology using Etest for MIC determination of ceftriaxone, cefixime, azithromycin, spectinomycin and ciprofloxacin. The current clinical resistance breakpoints from the European Committee on Antimicrobial Susceptibility Testing (EUCAST; https://www.eucast.org/clinical_breakpoints, v14.0) were used. Since January 2019, EUCAST does not state any clinical resistance breakpoint for azithromycin and in this report, the Epidemiological Cut-Off (ECOFF), distinguishing isolates with azithromycin resistance mechanisms, is instead used for azithromycin.

In Table 3.13, the antimicrobial resistance in clinical gonococcal isolates cultured in 2023 are compared with those from 2013 to 2022. Briefly, the level of resistance to ciprofloxacin remains very high (65% in 2023). The proportion of isolates above the azithromycin ECOFF (MIC>1 mg/L) was 33%, which represents a small increase since 2022 (30%). Sixteen (0.65%) isolates were high-level azithromycin resistant (MIC≥256 mg/L). Notably, 94% of the isolates with an azithromycin MIC above the azithromycin ECOFF had an MIC of 2-4 mg/L, i.e. only 1-2 MIC doubling dilution above the ECOFF. It remains unknown if these isolates would fail clinical treatment with azithromycin 2 g, and a clinical resistance breakpoint for azithromycin would be valuable. Resistance to cefixime decreased slightly from 1.2% in 2022 to 0.4% in 2023. For the second consecutive year since 2014, ceftriaxone resistant isolates (n=3, 0.1%) were identified in Sweden. Ceftriaxone is the last remaining option for empirical antimicrobial monotherapy of gonorrhoea and it is a major concern if ceftriaxone resistant strains will start to spread widely, which has been observed recently in some Asian countries such as China, Japan, Cambodia, and Vietnam. No gonococcal isolates resistant to spectinomycin have been detected in Sweden yet. However, the availability of spectinomycin can be limited (in Sweden as in most countries globally), and it is not suitable as monotherapy for pharyngeal gonorrhoea.

Neisseria meningitidis, mandatory reporting

Invasive meningococcal disease is a notifiable disease and in 2023, 33 cases (0.3 cases per 100 000 inhabitants) were reported. This represents an ongoing slow increase from the low numbers displayed during 2020 to 2022, likely associated with the COVID-19 pandemic restrictions, e.g. social and physical distancing and travel restrictions. However, despite the increase in incidence of the disease 2023, the number is still lower than in the years before the COVID-19 pandemic (66 cases in 2019). Typing of 31 of the 33 clinical invasive isolates from blood and/or cerebrospinal fluid and joint fluid (one isolate per patient) in 2023 was performed at the Swedish National Reference Laboratory for Neisseria meningitidis (an external body of the Public Health Agency of Sweden), Department of Laboratory Medicine, Clinical Microbiology, Örebro University Hospital and cultures were performed on 26 isolates.

Antimicrobial susceptibility testing was performed according to standardised and quality assured methodology using Etest for determination of MIC values for penicillin G, cefotaxime, meropenem, chloramphenicol, ciprofloxacin and rifampicin. The clinical resistance breakpoints determined by The European Committee on Antimicrobial Susceptibility Testing (EUCAST; https://www.eucast.org/clinical_breakpoints, v14.0) were used. Production of β-lactamase was examined by nitrocefin solution.

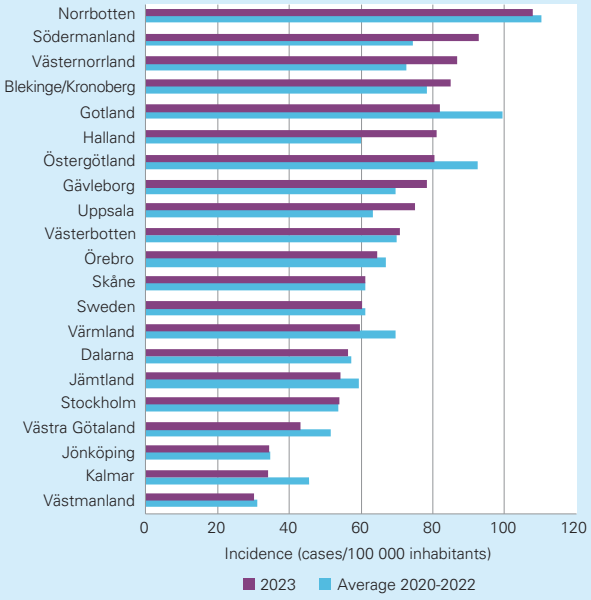
Five (19%) isolates were resistant to penicillin G (MIC=0.5 mg/L (n=4) and MIC=1 mg/L (n=1)). All isolates (100%) were susceptible to cefotaxime (MIC values of 0.002-0.032 mg/L), meropenem (MICs: 0.004-0.064 mg/L), chloramphenicol (MICs: 0.5-2 mg/L), ciprofloxacin (MICs: <0.002-0.008 mg/L) and rifampicin (MICs: <0.002-0.25 mg/L). None of the isolates obtained in 2023 produced β-lactamase. In fact, no β-lactamase-producing meningococcal isolate has ever been identified in Sweden.

Clostridioides difficile

Incidence of CDI

In 2023, 6 355 new CDI cases were reported corresponding to an incidence of 60 cases per 100 000 inhabitants (data corrected for reccurent CDI for one laboratory reporting all cases and missing data for one laboratory). Which is similar to the average value of the last three years (incidence 61). As in previous years, there are major differences between regions (spread 30-108 cases per 100 000 inhabitants; Figure 3.35).

Figure 3.35. The incidence of new cases with *C. difficile* (cases/ 100 000 inhabitants) by region in 2023 and average for the years 2020-2022. The regions are ranked from highest to lowest incidence in 2023. A case is considered new if at least eight weeks have elapsed since the previous positive test, otherwise it is counted as an ongoing illness episode or recurrence.



Source: The Public Health Agency of Sweden

Zoonotic pathogens: *Campylobacter*

Mandatory reporting of *Campylobacter*

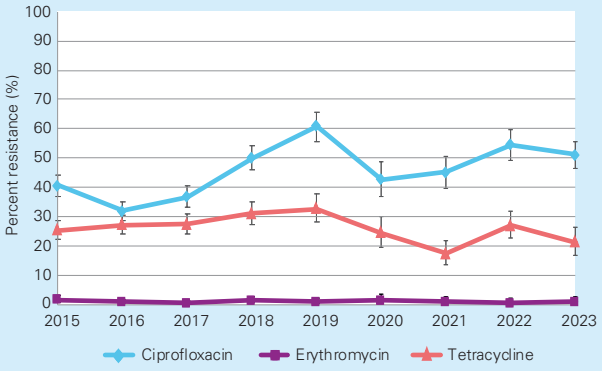
- Total number of reported cases: 5 676 (previous year: 5 165)

The majority of notified cases, 53%, were reported as acquired in Sweden. The proportion of domestic infections decreased slightly compared to the previous year. The proportion of cases infected abroad was 44%, similar to the previous year, reaching pre-pandemic levels.

Campylobacter jejuni, from faecal samples

A total of 1 898 *Campylobacter* species were found in faecal sampling. Four-fifths of the isolates were reported as *C. jejuni*, 12% as *C. jejuni/C. coli* and the rest were other species. The presence of AST data, and in a sufficient number of isolates, was highest for *C. jejuni* (28 % of all reported isolates). For *C. jejuni*, resistance to ciprofloxacin was 56% and 26% for tetracycline in 2023. Resistance to erythromycin was 1.9% (Figure 3.36). The proportion of isolates fully susceptible to erythromycin, ciprofloxacin and tetracycline was 45% and fully resistant was 1.2% (Table 3.14). It should be noted that

Figure 3.36. Antibiotic resistance in *Campylobacter jejuni* from faecal samples 2015-2023. The numbers of AST isolates for all years and antibiotics ranges from 254 to 816. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Table 3.14. Combined susceptibility and resistance to erythromycin, ciprofloxacin and tetracycline in *Campylobacter jejuni* from faecal samples 2015-2023.

Sample: Faeces	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of AST isolates	**659**	**793**	**697**	**544**	**352**	**253**	**304**	**360**	**331**
Proportion suseptitible to erythromycin, ciprofloxacin and tetracycline, %	54	61	60	47	38	56	53	43	45
Proportion resistant to erythromycin, ciprofloxacin and tetracycline, %	1.4	0.8	0.4	0.9	0.6	1.2	0.3	0.3	1.2

the number of isolates with combined AST is low. Only four fully resistant isolates were reported.

Comments

During 2018-2019, the majority of notifiable campylobacter infections were acquired abroad. During the pandemic years, 2020-2021, the total number of notified cases decreased and the proportion of cases infected in Sweden increased. Resistance to ciprofloxacin and tetracycline was slightly lower in 2020 and 2021, compared to 2019. In 2016 and 2017, there was a large outbreak of campylobacter in humans linked to domestic poultry production. During these two years, the proportion of isolates of Swedish origin was higher. It can be noted that the resistance to ciprofloxacin was lower 2016-2017 (Figure 3.36) and a higher percentage of isolates were fully susceptible (Table 3.14).

Salmonella

Mandatory reporting of *Salmonella*

Infection with *Salmonella* species are divided into three notifiable diseases in Sweden: infection with *Salmonella enterica* (*S.* Typhi and *S.* Paratyphi excluded), typhoid fever and paratyphoid fever. In addition, cases with *Salmonella* carrying ESBL or $ESBL_{CARBA}$ are also notifiable in the mandatory reporting of ESBL-producing Enterobacterales.

- Total number of reported cases with *Salmonella enterica*: 1 316 (previous year: 1 137)
- Total number of reported cases with typhoid fever: 27 (previous year: 14)
- Total number of reported cases with paratyphoid fever: 12 (previous year: 8)
- Total number of *Salmonella* carrying ESBL: 12 (previous year: 21)
- Total number of *Salmonella* carrying $ESBL_{CARBA}$: 0 (previous year: 0)

In 2023, the majority of the notifiable *Salmonella* cases, 53%, were reported as acquired abroad. Cases with *Salmonella* acquired in Sweden constituted 45% of all cases. Information about country of acquisition was lacking for 2%. The distribution of country of acquisition seems to return to the distribution seen pre-pandemic, although the number of cases is considerbly lower compared to 2019 and the years before. No cases were reported with *Salmonella* species carrying $ESBL_{CARBA}$.

Table 3.15. Poportion (%) of antibiotic resistance in *Salmonella enterica* (S. Typhi and S. Paratyphi excluded) isolated from blood or from faeces and urine samples in 2023. NA: not applicable..

Antibiotic	Blood isolates, % R (n = 136)	Faeces and urine, % R (n= 512)
Azithromycin	2.2	2.0
Cefotaxime	2.9	2.0
Ceftazidime	3.0	1.8
Fluoroquinolone	26.7	23.6
Meropenem	0.0	0.0
Piperacillin-tazobactam	2.3	2.7
Trimethoprim-sulphamethoxazole	4.4	5.3

Salmonella spp., from blood or faecal and urine samples

A total of 1 404 *Salmonella enterica* isolates were reported in Svebar, with 71% from faecal samples, 17% from blood and 8% from urine. In 2023, there were 239 isolates of *Salmonella* reported in blood and 996 isolates from feaces. For both sampling materials, approximately half had an AST reported. A comparison for 2023 is presented in Table 3.15.

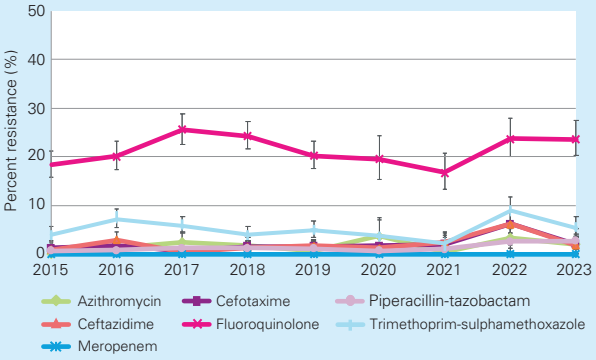
Table 3.16. Antibiotic resistance in *Salmonella enterica* from blood samples 2016-2023. Results for *S.* Typhi and *S.* Paratyphi are excluded. The numbers of AST isolates for all years and antibiotics ranges from 32 to 136.

	2016			2017			2018			2019			2020			2021			2022			2023		
Sample: Blood	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI	n	% R	95% CI
Azithromycin	47	0.0	(0.0-7.6)	75	4.0	(1.4-11.1)	64	4.7	(1.6-12.9)	70	0.0	(0.0-5.2)	32	3.1	(0.6-15.7)	52	3.8	(1.1-13.0)	73	0.0	(0.0-5.0)	93	2.2	(0.6-7.5)
Cefotaxime	73	2.7	(0.8-9.5)	107	0.9	(0.2-5.1)	92	0.0	(0.0-4.0)	125	1.6	(0.4-5.6)	59	10.2	(4.7-20.5)	76	7.9	(3.7-16.2)	95	5.3	(2.3-11.7)	136	2.9	(1.1-7.3)
Ceftazidime	73	2.7	(0.8-9.5)	103	1.0	(0.2-5.3)	87	0.0	(0.0-4.2)	124	1.6	(0.4-5.7)	57	10.5	(4.9-21.1)	76	7.9	(3.7-16.2)	94	4.3	(1.7-10.4)	135	3.0	(1.2-7.4)
Fluoroquinolone	65	12.3	(6.4-22.5)	100	25	(17.5-34.3)	90	27.8	(19.6-37.8)	117	27.4	(20.1-36.1)	59	32.2	(21.7-44.9)	74	25.7	(17.1-36.7)	95	32.6	(24.0-42.6)	135	26.7	(19.9-34.7)
Meropenem	73	0.0	(0.0-5.0)	107	0.0	(0.0-3.5)	93	0.0	(0.0-4.0)	125	0.0	(0.0-3.0)	59	0.0	(0.0-6.1)	76	0.0	(0.0-4.8)	95	0.0	(0.0-3.9)	136	0.0	(0.0-2.7)
Piperacillin-tazobactam	71	0.0	(0.0-5.1)	100	2.0	(0.6-7.0)	89	0.0	(0.0-4.1)	123	0.0	(0.0-3.0)	56	3.6	(1.0-12.1)	73	0.0	(0.0-5.0)	90	1.1	(0.2-6.0)	133	2.3	(0.8-6.4)
Trimethoprim-sulfamethoxazole	70	8.6	(4.0-17.5)	105	9.5	(5.3-16.6)	93	3.2	(1.1-9.1)	125	6.4	(3.3-12.1)	59	15.3	(8.2-26.5)	76	1.3	(0.2-7.1)	95	7.4	(3.6-14.4)	135	4.4	(2.1-9.4)

Comments

In previous years, the number of isolates found in blood with an AST has ranged between 47-125 per year and antibiotic (Table 3.16). The data may contain duplicates and there is a risk of overestimation of the resistance. Hence, results should be interpreted with caution. The general increase in resistance among faecal and urine isolates seen in 2022 (Figure 3.37), probably linked to the increase of *Salmonella* isolates carrying ESBL, decreased in 2023 for several antibiotics. Resistance to cefotaxime decreased to 2% in 2023. Three-quarters of the *Salmonella* from faecal and urine samples were fully susceptible to azithromycin, cefotaxime and ciprofloxacin (Table 3.17). During 2015-2023, no carbapenem-resistent *Salmonella* have been reported.

Figure 3.37. Antibiotic resistance in *Salmonella enterica* from faecal and urine samples 2015-2023. Results from *S.* Typhi and *S.* Paratyphi have been excluded. The numbers of AST isolates for all years and antibiotics ranges from 187 to 875. The exact numbers are given in the attached file.



Source: The Public Health Agency of Sweden

Table 3.17. Combined susceptibility and resistance to azithromycin, cefotaxime and ciprofloxacin in *Salmonella enterica* from faecal and urine samples 2015-2023. Results from *S.* Typhi and *S.* Paratyphi have been excluded.

Sample: Faeces and urine	2015	2016	2017	2018	2019	2020	2021	2022	2023
Number of isolates with combined AST for azithromycin, cefotaxime and ciprofloxacin	424	328	426	454	404	183	267	327	342
Proportion fully suseptitible to azithromycin, cefotaxime and ciprofloxacin, %	80	75	74	76	79	77	79	73	76
Proportion fully resistant to azithromycin, cefotaxime and ciprofloxacin, %	0.0	0.6	0.0	0.2	0.3	0.0	0.0	1.5	0.0

Antibiotic resistance in animals

Notifiable diseases

In Sweden, findings of carbapenemase-producing Enterobacterales ($ESBL_{CARBA}$) and methicillin-resistant coagulase-positive staphylococci in animals are notifiable (SJVFS 2021:10 and previously SJVFS 2012:24 with amendments). In the monitoring, the attention regarding methicillin-resistant coagulase-positive staphylococci is mainly directed towards methicillin-resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus pseudintermedius* (MRSP). Furthermore, as Enterobacterales producing classical ESBLs ($ESBL_A$) or plasmid-mediated AmpC ($ESBL_M$) as well as vancomycin resistant enterococci (VRE) are notifiable when detected in humans, specific attention is also paid to these bacteria in animals.

ESBL-producing Enterobacterales

Healthy farm animals

Escherichia coli

In Sweden, $ESBL_{CARBA}$ in animals are notifiable but not $ESBL_A$ or $ESBL_M$. During 2023, various samples from healthy farm animals were screened for *Escherichia coli* resistant to ESCs and carbapenems using selective media. Isolates with reduced susceptibility were further investigated by genome sequencing for presence of transferable genes coding for ESC resistance (for details see Material and methods, resistance in bacteria from animals).

Active screening for *E. coli* resistant to ESCs in healthy farm animals using faecal samples collected at slaughter has been performed since 2008. The proportions of samples positive for *E. coli* with $ESBL_A$ or $ESBL_M$ in screenings of healthy animals are available as supplementary material on the SVA web page (www.sva.se/svarm).

Fattening pigs

Samples from fattening pigs were collected at slaughter under the supervision of the National Food Agency (SLV) at six abattoirs that together processed more than 85% of the total number of pigs slaughtered in Sweden 2023. The number of samples from each abattoir was roughly proportional to the annual slaughter volume of the abattoir. Each sample was randomly selected but represented a unique herd per day. Samples were sent to SVA for culture the same day or the next day after collecting and in meantime kept refrigerated.

Carbapenem resistant *Escherichia coli* was not isolated from any of 302 investigated samples.

Escherichia coli with ESC-resistance was isolated from 10 (3%) of 302 investigated samples and a transferable gene coding for ESC resistance was detected in 3 isolates, i.e. 1% of the samples (Table 4.1). Two of the isolates with a transferable gene had an $ESBL_A$ phenotype and carried $bla_{CTX\text{-}M\text{-}15}$. The third isolate with a transferable gene had an $ESBL_M$ phenotype and carried $bla_{DHA\text{-}1}$. The remaining seven isolates with ESC-resistance all had an AmpC phenotype and genome sequencing revealed a mutation causing hyper-production of AmpC beta-lactamases, i.e. a shift from C to T at position 42 of the ampC promoter.

Two of the isolates with transferable ESC-resistance were also resistant to azithromycin, sulphonamides, trimethoprim, tetracycline, and quinolones. Furthermore, one of these isolates was also resistant to chloramphenicol. The third isolate with transferable ESC-resistance was only resistant to ciprofloxacin apart from resistance to beta-lactams, including ESCs. Among the isolates without transferable ESC-resistance, one isolate was resistant to tetracycline, two isolates were resistant to sulphonamides and trimethoprim, and four isolates were only resistant to beta-lactams, including ESCs.

The proportion of samples with ESC-resistant *E. coli* (3%) was lower than in previous years (8% in 2021 and 12-13% in 2015-2019). If this is an actual change or only a coincidence is not known. Nor what would be the reasons for such a change. The proportion of samples with transferable ESC resistance has always been lower and hence the difference is less visible for this subset.

Broilers

Samples from broilers were randomly selected among caeca collected at slaughter within the Swedish Campylobacter programme, in which whole caeca are collected from each batch of broilers slaughtered. From these samples, 50 were selected in February-March and 50 in November-December. Each sample was from a unique flock but not always from a unique production site. Samples cultured were collected at seven abattoirs that in 2023 accounted for approximately 98% of the total volume of broilers slaughtered. The number of samples from each abattoir was roughly proportional to the annual slaughter volume of the abattoir and the sampling was distributed over the year.

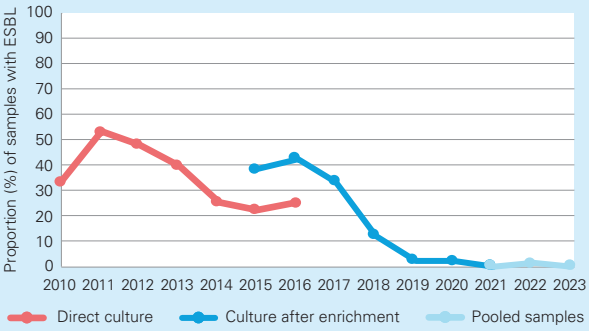
Carbapenem resistant *Escherichia coli* was not isolated from any of 100 investigated samples.

Escherichia coli with ESC-resistance was isolated from 1 (1%) of 100 investigated samples and a transferable gene coding for ESC resistance was detected in this isolate (Table 4.1). The isolate with a transferable gene had an $ESBL_A$ phenotype and carried $bla_{TEM\text{-}52}$. No other resistance than to beta-lactams, including ESCs, was detected in the isolate.

Due to differences in methodology over the years, changes in the proportion of positive samples over the whole time period cannot be directly assessed. However, some comparison with earlier years is possible as the samples from 2015 and the first half of 2016 as well as the samples from 2021 were cultured in duplicate with both methods that were relevant for the respective years (for details on methodology see Material and methods, resistance in bacteria from animals in relevant Swedres-Svarm reports). The difference in the proportion of broiler caecal samples positive for *E. coli* with

$ESBL_A$ or $ESBL_M$ since 2016 is statistically significant ($p<0.01$, X^2; Figure 4.1). This decrease is most likely explained by decreased occurrence of such bacteria in the breeding pyramid as described by Nilsson et al. (2020).

Figure 4.1. Proportion (%) of samples from broilers positive for *Escherichia coli* with $ESBL_A$ or $ESBL_M$ from 2010 to 2023. The number of samples each year varies (n=100-305, 2023 n=100).



Meat samples

Escherichia coli

In Sweden, neither carbapenemase-producing Enterobacterales ($ESBL_{CARBA}$), nor classical ESBLs ($ESBL_A$) or plasmid-mediated AmpC ($ESBL_M$) are notifiable in food. Active screening for *Escherichia coli* resistant to ESCs in meat samples collected at retail has been performed since 2008. During 2023, pig and cattle meat samples were screened for *E. coli* resistant to ESCs and carbapenems using selective media (for details see Material and methods, resistance in bacteria from animals).

Samples from pig and cattle meat were collected at retail by municipal environmental departments in twelve different municipalities in Sweden. The samples were distributed throughout the year and among the municipalities in order to get a representative sampling. Furthermore, consignments of pig and cattle meat from countries outside EU imported via border control posts in Sweden were sampled by personnel from the National Food Agency (SLV).

The proportions of samples positive for *E. coli* with $ESBL_A$ or $ESBL_M$ in screenings of meat sampled at retail are available as supplementary material on the SVA web page (www.sva.se/svarm).

Pig meat

A total of 298 samples of fresh pig meat were collected at retail. The samples comprised meat originating both from Sweden (n=267) and other EU countries (n=31).

Escherichia coli with carbapenem resistance or ESC-resistance were not isolated from any of the samples of pig meat collected at retail (Table 4.1).

In addition, one consignment of pig meat from a country outside EU was sampled at border control post. From this consignment, three samples were analysed.

Escherichia coli with carbapenem resistance or ESC-resistance were not isolated from any of the samples of pig meat collected at border control post.

Cattle meat

A total of 304 samples of fresh cattle meat were collected at retail. The samples comprised meat originating both from Sweden (n=282), other EU countries (n=21), and from outside EU (n=1).

Escherichia coli with carbapenem resistance or ESC-resistance were not isolated from any of the samples of cattle meat (Table 4.1).

In addition, three consignments of cattle meat from countries outside EU were sampled at border control posts. From these consignments, nine samples were analysed.

Escherichia coli with carbapenem resistance or ESC-resistance were not isolated from any of the samples of cattle meat collected at border control posts.

Clinical isolates from companion animals and horses

In Svarm, there are no recurring active screenings for ESBL-producing Enterobacterales in healthy companion animals or horses. However, results of the screenings for ESC resistant *E. coli* that have been performed are available as supplementary material on the SVA web page (www.sva.se/svarm).

For a number of years, funding from the Swedish Board of Agriculture has enabled SVA to perform confirmation of suspected ESC-resistance in clinical isolates of Enterobacterales free of charge for referring laboratories. During 2023, 44 submitted isolates of Enterobacterales with phenotypic resistance to ESCs from companion animals and horses were confirmed to produce $ESBL_A$ and/or $ESBL_M$ by genome sequencing (Table 4.2). The isolates were from cats (n=2), dogs (n=14) and horses (n=28). The majority of the isolates from cats and dogs were *E. coli* and the most common gene was $bla_{CTX\text{-}M\text{-}15}$. For horses, the majority of the isolates were the *Enterobacter cloacae* group and the most common gene was $bla_{SHV\text{-}12}$. Data regarding clinical isolates from cats, dogs and horses confirmed to produce $ESBL_A$ and/or $ESBL_M$ is available as supplementary material on the SVA web page (www.sva.se/svarm).

Assessment of resistance to substances besides beta-lactams including ESCs is hampered as ECOFFs for many combinations of bacteria and substances are not defined. However, about three quarters of the investigated isolates were also resistant to at least two other antibiotics, i.e. multiresistant. The most common resistances were against gentamicin (70%)

Table 4.1. Proportion (%) of samples from broilers, pigs, cattle meat, and pig meat positive for *Escherichia coli* with $ESBL_A$ or $ESBL_M$, 2023. Most recent data on occurrence of *E. coli* with $ESBL_A$ or $ESBL_M$ from other sample categories are given for comparison.

Origin and year	Broilers (2023)	Cattle (2020-21)	Laying hens (2022)	Pigs (2023)	Turkey (2022)	Broiler meat (2022)	Cattle meat (2023)	Pig meat (2023)	Turkey meat (2022)
Swedish	1	12	2	1	0	0	0	0	0
Non-Swedish	–	–	–	–	–	25	0	0	–

and trimethoprim-sulphonamides (66%). Resistance to quinolones and tetracycline were also common traits. For the years 2021-2023 the occurrence of resistance to quinolones was slightly higher among isolates from companion animals than among isolates from horses. On the contrary, the occurrence of resistance to gentamicin and trimethoprim-sulphonamides was higher among isolates from horses than among isolates from companion animals (Table 4.3).

Table 4.2. Clinical isolates of different bacterial species of Enterobacterales, producing $ESBL_A$ or $ESBL_M$, from companion animals and horses, 2023.

Animal species	Beta-lactamase		Bacterial species	No. of isolates
	group	gene		
Cats	**All**	**All**	**Enterobacterales**	**2**
	CIT	CMY-2	*Escherichia coli*	1
	CTX-M-9	CTX-M-27	*Escherichia coli*	1
Dogs	**All**	**All**	**Enterobacterales**	**14**
	CIT	CMY-2	*Escherichia coli*	5
		CMY-4	*Escherichia coli*	1
	CTX-M-1	CTX-M-15	*Escherichia coli*	4
		CTX-M-3	*Escherichia coli*	1
	CTX-M-9	CTX-M-27	*Escherichia coli*	3
Horses	**All**	**All**	**Enterobacterales**	**28**
	CTX-M-1	CTX-M-1	*Escherichia coli*	1
			Enterobacter cloacae group	1
			Citrobacter species	1
		CTX-M-15	*Klebsiella pneumoniae*	3
	SHV	SHV-12	*Escherichia coli*	4
			Enterobacter cloacae group	16
			Klebsiella species	1
	SHV+ACT	SHV-12+ACT-7	*Enterobacter cloacae* group	1

Table 4.3. Resistance (%) in clinical isolates of different bacterial species of Enterobacterales, producing $ESBL_A$ or $ESBL_M$, from companion animals and horses, 2021-2023.

Antibiotic	Breakpoint used (mg/L)	Resistance (%)	
		Dogs and cats (n=50)	Horses (n=75)
Enrofloxacin	0.12	44	31
Gentamicin	2	26	89
Neomycin	8	4	31
Tetracycline	8	16	21
Trim-Sulph.[a]	0.5	46	83

Methicillin-resistant *Staphylococcus aureus* (MRSA)

In Sweden, methicillin-resistant *Staphylococcus aureus* (MRSA) in animals was first verified in 2006 and made notifiable in 2008. Since then, most cases in domesticated animals have been detected in passive monitoring of clinical sampling in infected animals. Isolates of *S. aureus* with resistance to oxacillin or cefoxitin have been further analysed with confirmatory tests. Screening studies for active monitoring have been performed in pigs, cattle, horses, dogs, and hedgehogs during different years (see below). Cases from 2023 are presented in Table 4.4 and data regarding index cases of clinical isolates and isolates from screenings is available as supplementary material on the SVA web page (www.sva.se/svarm).

Farm animals

Screening studies in pigs have been performed five times since 2006, with only two positive samples from pigs at slaughter in 2010. The most recent screening was performed in all 39 nucleus and multiplying herds present in 2014 and all samples were negative. Other herd types have not been investigated since 2010. Therefore, information about the occurrence of MRSA in Swedish pig herds is currently not complete.

In dairy cattle, active monitoring of selected isolates of beta-lactamase producing *S. aureus* from milk samples has been ongoing since 2010, and about 1 400 isolates have been tested up to and including 2023. The monitoring is performed on isolates with anonymised origin. Since 2010 five PVL-negative isolates with *mecC*, two PVL-negative isolates with *mecA* and one PVL-positive isolate with *mecA* have been detected. In 2023 no MRSA was detected of the 50 isolates screened for occurrence of *mecA* and *mecC*. In 2012, PVL-positive MRSA with *mecA* was isolated from several animals in a dairy herd (Unnerstad et al., 2018).

In 2016 and early 2017 there was an outbreak of MRSA with *mecC* among goats and sheep connected to a zoo. In addition, MRSA with *mecC* was found in eight out of twenty-one

Table 4.4. Isolates of methicillin-resistant *Staphylococcus aureus* (MRSA) in Swedish animals 2023. All isolates were positive for the *nuc* gene and *mecA* or *mecC* genes. One isolate was not available for further testing and is not included in the table. Shaded areas indicate MIC above EUCAST ECOFF.

		Antibiotic, MIC (mg/L)										
Animal species	**Beta-lactams**	**Cli**	**Ery**	**Tet**	**Fus**	**Gen**	**Cip**	**Tmp**	**Chl**	**Lin**	***spa*-type**	***mec*-gene**
Cat	R	0.25	>8	≤0.5	≤0.25	≤0.5	≤0.25	≤1	8	2	t026	*A*
Cat	R	0.25	0.5	>16	≤0.25	>16	1	2	8	2	t011	*A*
Cat	R	0.25	0.5	≤0.5	≤0.25	≤0.5	≤0.25	≤1	8	2	t843	*C*
Cat	R	≤0.12	0.5	≤0.5	≤0.25	≤0.5	0.5	2	8	2	t359	*A*
Cat	R	≤0.12	≤0.25	≤0.5	≤0.25	≤0.5	0.5	≤1	8	2	t002	*A*
Cat	R	≤0.12	≤0.25	≤0.5	≤0.25	≤0.5	≤0.25	≤1	8	≤1	t843	*C*
Dog	R	>4	>8	≤0.5	≤0.25	16	8	2	32	2	t430	*A*
Dog	R	>4	≤0.25	>16	≤0.25	1	8	>16	8	≤1	t011	*A*
Dog	R	0.25	0.5	>16	>4	>16	≤0.25	≤1	8	2	t491	*A*
Dog	R	0.25	≤0.25	≤0.5	≤0.25	≤0.5	≤0.25	≤1	8	2	t843	*C*
Dog	R	≤0.12	0.5	>16	≤0.25	>16	≤0.25	>16	8	2	t011	*A*
Dog	R	≤0.12	0.5	≤0.5	>4	≤0.5	0.5	2	8	2	t3468	*A*
Dog	R	≤0.12	0.5	≤0.5	≤0.25	1	≤0.25	≤1	8	2	t304	*A*
Dog	R	≤0.12	≤0.25	≤0.5	>4	>16	0.5	≤1	8	2	t267	*A*
Dog	R	≤0.12	≤0.25	≤0.5	>4	≤0.5	>8	>16	8	2	t3841	*A*
Horse	R	0.25	>8	≤0.5	≤0.25	16	≤0.25	2	8	2	t002	*A*
Horse	R	0.25	0.5	>16	≤0.25	>16	≤0.25	>16	16	4	t011	*A*
Horse	R	0.25	0.5	>16	≤0.25	>16	≤0.25	>16	8	2	t011	*A*
Horse	R	0.25	0.5	>16	≤0.25	16	0.5	>16	8	2	t011	*A*
Horse	R	≤0.12	0.5	>16	≤0.25	>16	1	>16	8	2	t011	*A*
Horse	R	≤0.12	0.5	>16	≤0.25	>16	1	>16	8	2	t011	*A*
Horse	R	≤0.12	0.5	>16	≤0.25	16	≤0.25	>16	8	2	t011	*A*
Horse	R	≤0.12	0.5	>16	≤0.25	8	0.5	>16	8	2	t011	*A*
Horse	R	≤0.12	0.5	≤0.5	>4	≤0.5	>8	>16	8	2	t3841	*A*
Horse	R	≤0.12	≤0.25	>16	≤0.25	>16	2	>16	8	2	t011	*A*
Horse	R	≤0.12	≤0.25	>16	≤0.25	16	0.5	>16	8	2	t011	*A*

sampled goats in a herd in 2017 and in one goat sold from the same herd. In 2019 an additional goat herd with MRSA was identified. The farm had an epidemiological link to the herd detected in 2017 and shared the same *spa*-type, t373. In total six goats were sampled, and samples were pooled two and two for cultivation with all pools being positive for *mecC*-MRSA. In 2019, twenty-two dairy goat herds were screened for occurrence of MRSA, using bulk-milk samples and pooled swabs, with no positive samples found (Persson et al., 2021).

Companion animals and horses

Up to and including 2023, a total of 253 cases of MRSA in companion animals and horses have been confirmed. These include 75 dogs, 52 cats, 2 rabbits, 1 parrot and 123 horses. In these animal species, there is currently no regular active monitoring of MRSA, but screenings in dogs were performed in 2006 and 2012 without detection of MRSA. Furthermore, a study on 325 healthy dogs in 2017-2018 detected no MRSA or other methicillin-resistant coagulase positive staphylococci (Börjesson et al., 2020). Screening studies in horses have been performed twice, in 2007 and 2010, with one positive sample in 2007.

In 2023, MRSA was detected in clinical samples, from wound infections, urine, joint and abscesses, from nine dogs and six cats (Table 4.4). During the years the identified *spa*-types have varied, and most have previously been detected in humans but one cat and two dogs carried the horse-related t011 (supplementary material on the SVA web page, www.sva.se/svarm).

In 2023, MRSA was isolated from 12 horses which is fewer cases compared to the figures in 2020-2022, but still more cases compared to previous years (2007-2019) when between one and nine cases were notified per year (supplementary material on the SVA web page, www.sva.se/svarm). In 2020 and 2021 the increase was partly explained by gathered cases at outbreaks of MRSA in equine hospitals (*spa*-type t1971, t034 and t011). Historically, MRSA *spa*-type t011, has been dominating among horses in Sweden and in 2023 the *spa*-type was detected in ten of the twelve cases. The remaining two MRSA were one each of spa-types t002 and t3841 (Table 4.4). All the mentioned *spa*-types have also been detected more or less frequently in MRSA from humans.

Wild animals

High occurrence of *mecC*-MRSA has been described in hedgehogs in Sweden, 64%, Denmark, 61% (Bengtsson et al., 2017 and Rasmussen et al., 2019) and other countries. Recent studies suggest that *mecC*-MRSA likely originate from hedgehogs, as the result of selective pressure of beta-lactams produced by dermatophytes, and that this occurred long before introduction of clinically used antibiotics (Larsen et al., 2022).

Methicillin-resistant *Staphylococcus pseudintermedius* (MRSP)

In 2023, there were 46 MRSP cases from 44 dogs and two cats reported to the Swedish Board of Agriculture. This number is about the same level as in previous years (Figure 4.2).

All but one isolate were available for further susceptibility testing and genome sequencing. Information on the sampling site was available for 38 cases; wounds 16 cases, skin 11 cases, external ear canal 3 cases, urine 3 cases, and the remaining 5 were isolated from various other sites or from pooled samples. For resistance phenotypes, see Table 4.5.

The results of the genome sequencing of 44 isolates, divided the isolates into 30 different multi-locus sequence types, of which ST551 was the most common type with 11 isolates. The ST551 was first detected in 2016 and was also the most common ST in the last five years. In earlier years, ST71, a sequence type spread in Europe and described by Perreten et al. (2010), dominated among Swedish isolates. In 2023 two isolates of this type was found. The other sequence types occurring in 2023 were ST265 (two isolates), ST496 (two isolates), ST1095 (two isolates) and single isolates of ST45, ST386, ST621, ST741, ST826, ST1331, ST1339, ST1602, ST1635, ST1782, ST2116, ST2119, ST2177, ST2275, ST2624, ST2683-89, ST2691-93. One isolate was not available for further testing and one isolate was not sequenced.

Figure 4.2. Number of cases of methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) isolated from animals in Sweden 2006-2023. In 2006-2007 the numbers represent the isolates that were sent to SVA and confirmed as *mecA*-positive and from 2008 the number of cases notified to the Swedish Board of Agriculture.

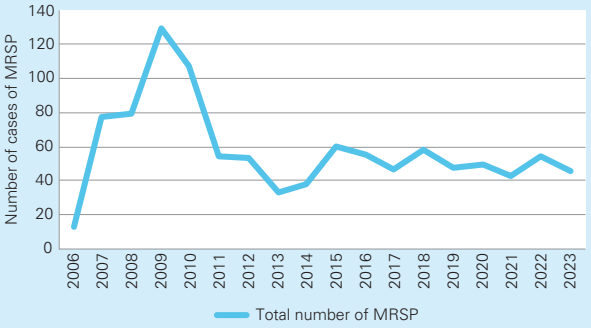


Table 4.5. Resistance phenotypes of isolates of methicillin resistant *Staphylococcus pseudintermedius* (MRSP) isolated from animals in Sweden 2023. All isolates were positive for the *mecA* gene. One isolate was not available for further testing and is not included in the table. Shaded areas indicate resistance.

	Antibiotic MIC (mg/L)								
Beta-lactams	Tet	Tsu	Ery	Cli	Gen	Enr	Fus	Nit	No. of isolates
R	>4	>4	>2	>2	4	>1	>2	≤16	1
R	>4	1->4	>2	>2	2->4	>1	≤0.5	≤16	21
R	>4	4->4	>2	>2	4->4	≤0.25	≤0.5	≤16	5
R	>4	>4	>2	>2	≤1	≤0.25	≤0.5	≤16	2
R	>4	>4	≤0.25	≤0.25	>4	≤0.25	≤0.5	≤16	1
R	>4	4	≤0.25	≤0.25	≤1	0.5	≤0.5	≤16	1
R	>4	0.5	>2	>2	>4	>1	≤0.5	≤16	3
R	>4	0.5	>2	>2	4	≤0.25	≤0.5	≤16	1
R	>4	0.5	>2	>2	≤1	1	≤0.5	≤16	1
R	>4	0.5	>2	>2	≤1	≤0.25	≤0.5	≤16	1
R	>4	0.5	>2	0.5	>4	>1	≤0.5	≤16	1
R	>4	0.5	≤0.25	≤0.25	4	>1	≤0.5	≤16	1
R	>4	≤0.25	≤0.5	≤0.5	≤1	≤0.25	≤0.5	≤16	1
R	≤0.25	4	>2	>2	>4	>1	≤0.5	≤16	1
R	≤0.25	1	>2	>2	≤1	≤0.25	≤0.5	≤16	1
R	≤0.25	≤0.25	>2	>2	≤1	≤0.25	>2	≤16	1
R	≤0.25	0.5	≤0.25	≤0.25	≤1	≤0.25	≤0.5	≤16	2

Zoonotic pathogens

Zoonoses are diseases that can be naturally transmitted between animals and humans. Antibiotic resistance in zoonotic bacteria such as *Salmonella* and *Campylobacter* from animals is therefore of direct public health concern.

Salmonella

Findings of *Salmonella* in animals are notifiable in Sweden. In Svarm, antibiotic susceptibility is determined in one isolate from each notified incident in animals each year, except for wild birds and cats (see below). Isolates from incidents previously notified but still under restrictions are also included. In incidents involving more than one serovar, one isolate of each serovar is tested. In the case of poultry, one isolate from each infected flock is included.

Isolates from wild birds are usually from cases of salmonellosis among passerines during the winter season and most *Salmonella* from cats are cases when cats have eaten these birds lying dead or diseased on the ground (Söderlund et al., 2019). Such isolates are often *S.* Typhimurium and susceptible to all tested antibiotics. Therefore, only a selection of these isolates is tested. For details on methodology, see Materials and methods, resistance in bacteria from animals.

A total of 107 *Salmonella enterica* ssp. *enterica* isolates were tested in 2023. Of all tested isolates, 78 were from domestic animals (Table 4.6). *Salmonella* Typhimurium was the most dominant serovar with 35 isolates, including a monophasic variant. Of these 31 were from domestic animals (Table 4.7). The highest number of isolates was from cattle (n=20) belonging to 6 different serovars dominated by *S.* Dublin. In pigs (n=19) *S.* Typhimurium was the dominating serovar and in poultry (n=12) *S.* Enteritidis.

The majority of the isolates (97 of 107; 90%) were susceptible to all antibiotics tested and all isolates from wildlife were fully susceptible. Distributions of MICs and resistance for all isolates from domestic animals are presented in Table 4.6 and for the subset *S.* Typhimurium in Table 4.7. Ten isolates were resistant to one or more antibiotics (Table 4.8). No interpretation was done for colistin due to uncertainties on ECOFFs and differences in MIC distributions between serovars. EUCAST does no longer suggest a colistin ECOFF for *Salmonella*. Ten isolates had an MIC of 4 mg/L for colistin (Table 4.6). These isolates were tested by PCR for presence of *mcr*-1 – *mcr*-9 genes, which may confer resistance to colistin, but all isolates were negative for these genes. Nine of these ten isolates belonged to serovar Dublin that often display slightly higher MIC to colistin than most other serovars and the tenth was an Enteritidis.

Table 4.6. Distribution of MICs and resistance (%) in *Salmonella enterica* ssp. *enterica* from domestic animals, 2023.

Antibiotic	Resistance %	Distribution (%) of MICs (mg/L)																
	n=78	≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Amikacin	1									98.7	1.3							
Ampicillin	8							83.3	7.7	1.3				7.7				
Azithromycin	0								12.8	5	37.2							
Cefotaxime	0					100												
Ceftazidime	0					74.4	23.1	2.6										
Chloramphenicol	1										97.4	1.3			1.3			
Ciprofloxacin	3	52.6	44.9			2.6												
Colistin[a]	NA							62.8	24.4	12.8								
Gentamicin	3						83.3	12.8	1.3				2.6					
Meropenem	0		97.4	1.3	1.3													
Nalidixic acid	3									97.4					2.6			
Sulphamethoxazole	6										12.8	5	30.8					6.4
Tetracycline	3								97.4					2.6				
Tigecycline	0					100												
Trimethoprim	4					83.3	11.5	1.3					3.8					

NA, not applicable.
[a]The isolates with colistin MIC >2 were tested with PCR for the *mcr-1* to *mcr-9* genes and found negative.

Table 4.7. Distribution of MICs and resistance (%) in *Salmonella* Typhimurium, including a monophasic variant, from domestic animals, 2023.

Antibiotic	Resistance %	Distribution (%) of MICs (mg/L)																
	n=31	≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Amikacin	3									96.8	3.2							
Ampicillin	13							74.2	12.9					12.9				
Azithromycin	0								9.7	71.0	19.4							
Cefotaxime	0					100												
Ceftazidime	0					71.0	29.0											
Chloramphenicol	3										96.8				3.2			
Ciprofloxacin	0	41.9	58.1															
Colistin	NA							71.0	29.0									
Gentamicin	0						80.6	19.4										
Meropenem	0		96.8	3.2														
Nalidixic acid	0									100								
Sulphamethoxazole	10										6.5	45.2	38.7					9.7
Tetracycline	6								93.5					6.5				
Tigecycline	0					100												
Trimethoprim	3					77.4	19.4						3.2					

NA, not applicable.

Table 4.8. MICs of fifteen antibiotics (mg/L) for the ten isolates of S*almonella enterica* ssp. *enterica* resistant to one or more substances, 2023. Shaded fields Indicate resistance.

Serovar	Source	Amp	Ctx	Caz	Mer	Gen	Amk	Sul	Tmp	Chl	Tet	Nal	Cip	Col	Azt	Tgz
Bovismorbificans	Horse	>32	≤0.25	≤0.25	≤0.03	>16	≤4	>512	>16	≤8	≤2	≤4	≤0.016	≤1	4	≤0.25
Bovismorbificans	Horse	>32	≤0.25	0.5	≤0.03	>16	≤4	>512	>16	≤8	≤2	≤4	≤0.016	≤1	8	≤0.25
Enteritidis	Poultry	≤1	≤0.25	≤0.25	≤0.03	≤0.5	≤4	32	≤0.25	≤8	≤2	>64	0.25	4	8	≤0.25
Enteritidis	Poultry	≤1	≤0.25	0.5	≤0.03	≤0.5	≤4	32	≤0.25	≤8	≤2	>64	0.25	2	8	≤0.25
Typhimurium	Cat	>32	≤0.25	≤0.25	≤0.03	≤0.5	≤4	32	0.5	≤8	≤2	≤4	≤0.016	≤1	4	≤0.25
Typhimurium	Cat	>32	≤0.25	≤0.25	≤0.03	≤0.5	≤4	16	≤0.25	≤8	≤2	≤4	≤0.016	≤1	4	≤0.25
Typhimurium	Pig	≤1	≤0.25	≤0.25	≤0.03	≤0.5	8	16	≤0.25	≤8	≤2	≤4	≤0.016	≤1	4	≤0.25
Typhimurium	Pig	>32	≤0.25	0.5	≤0.03	≤0.5	≤4	>512	0.5	>64	>32	≤4	≤0.016	≤1	4	≤0.25
Typhimurium[a]	Pig	>32	≤0.25	≤0.25	≤0.03	≤0.5	≤4	>512	≤0.25	≤8	>32	≤4	≤0.016	2	4	≤0.25
Typhimurium	Pig	≤1	≤0.25	0.5	≤0.03	1	≤4	>512	>16	≤8	≤2	≤4	0.03	≤1	4	≤0.25

[a]Monofasic variant.

Campylobacter

Campylobacter coli was isolated from samples of colon content from slaughter pigs collected at abattoirs for isolation of indicator bacteria. Isolates were species identified by MALDI-TOF MS. Samples from 181 pigs were cultured to isolate 176 *C. coli* and these samples were evenly distributed over the year. For details on methodology see Materials and methods, resistance in bacteria from animals.

Of the 176 isolates, 116 (66%) were susceptible to the six tested antibiotics. There was no resistance recorded against chloramphenicol, ertapenem, gentamicin or tetracycline (Table 4.9). One isolate was resistant to erythromycin. In *Campylobacter* spp. isolated directly from animals, erythromycin resistance has only been found once before, in 2017. As in 2017 analysis of whole genome sequencing of the macrolide resistant isolate revealed previously described target altering mutations in the 23S rRNA genes (A2059G, *E. coli* numbering) (Bolinger & Kathariou, 2017). No transferable macrolide resistance genes were found.

The level of quinolone resistance was comparable to previous years (Figure 4.3). Neither quinolones nor fluoroquinolones are authorised or used for treatment of groups of pigs via feed or water in Sweden. Additionally, a regulation (SJVFS 2023:21) has been restricting prescription of fluoroquinolones to animals in Sweden since 2013. Most of the consumption is in piglets treated individually with fluoroquinolones and to a lesser extent in other age categories (Sjölund et al., 2015). Any selection for quinolone resistance in *Campylobacter* therefore probably mainly occurs in sows and suckling piglets.

Figure 4.3. Ciprofloxacin resistance (%) in *Campylobacter coli* from pigs 2003-2023. During the years 2003-2005 enrofloxacin was tested instead of ciprofloxacin. The number of isolates per year has varied (n=83-176, 2023 n=176).

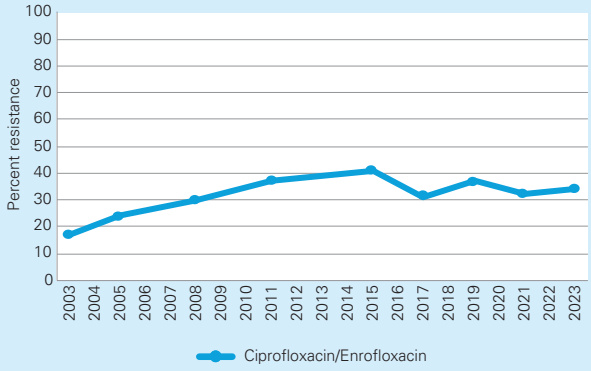


Table 4.9. Distribution of MICs and resistance (%) for *Campylobacter coli* from slaughter pigs, 2023.

Antibiotic	Resistance (%) n=176	Distribution (%) of MICs (mg/L) ≤0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Chloramphenicol	0					64.2	34.7	1.1							
Ciprofloxacin	34	59.7	6.3				0.6	15.9	15.9	1.7					
Ertapenem	0	97.7	2.3												
Erythromycin	<1				85.2	13.1	1.1								0.6
Gentamicin	0			29.0	70.5	0.6									
Tetracycline	0			99.4	0.6										

Clinical isolates from animals

Isolates tested are from clinical submissions of samples to SVA, if not otherwise stated. For many samples information on the indication for sampling was not available but the vast majority of submissions were likely from animals with infections. Therefore, data may be biased towards samples from treated animals or from herds where antibiotic treatment is common. Any assessments of trends are based on the assumption that this bias is inherent throughout the observation period. Furthermore, in some cases there are more than one animal sampled from the same herd. Likewise, regarding horses, dogs and cats, duplicates based on animal identity have not been excluded.

In Svarm, isolates are, when possible, classified as susceptible or resistant by ECOFFs issued by EUCAST (see Guidance for readers for details). This classifies isolates with acquired reduced susceptibility as resistant, which is relevant for monitoring purposes, but it should be understood that this does not always imply clinical resistance.

Pigs

Escherichia coli

Isolates of *E. coli* are from clinical submissions of faecal samples or samples taken post-mortem from the gastro-intestinal tract. The isolates are tested by PCR for genes coding for the virulence factors heat-labile enterotoxin (LT), heat-stable enterotoxin a and b (STa and STb), verocytotoxin (VT2e) and adhesion factors F4, F5, F6, F18 and F41. Only isolates with any of the mentioned virulence factors are included in Table 4.10.

As in previous years, resistance to ampicillin, tetracycline and trimethoprim-sulphamethoxazole were the most common

Figure 4.4. Resistance (%) in *Escherichia coli* from pigs 1995-2023 with a three-year moving average. Clinical isolates from faecal samples taken post-mortem from the gastrointestinal tract. The number of isolates each year varies (n=52-482, 2023=50). From 2020 and onwards, only results from isolates with virulence factors are shown.

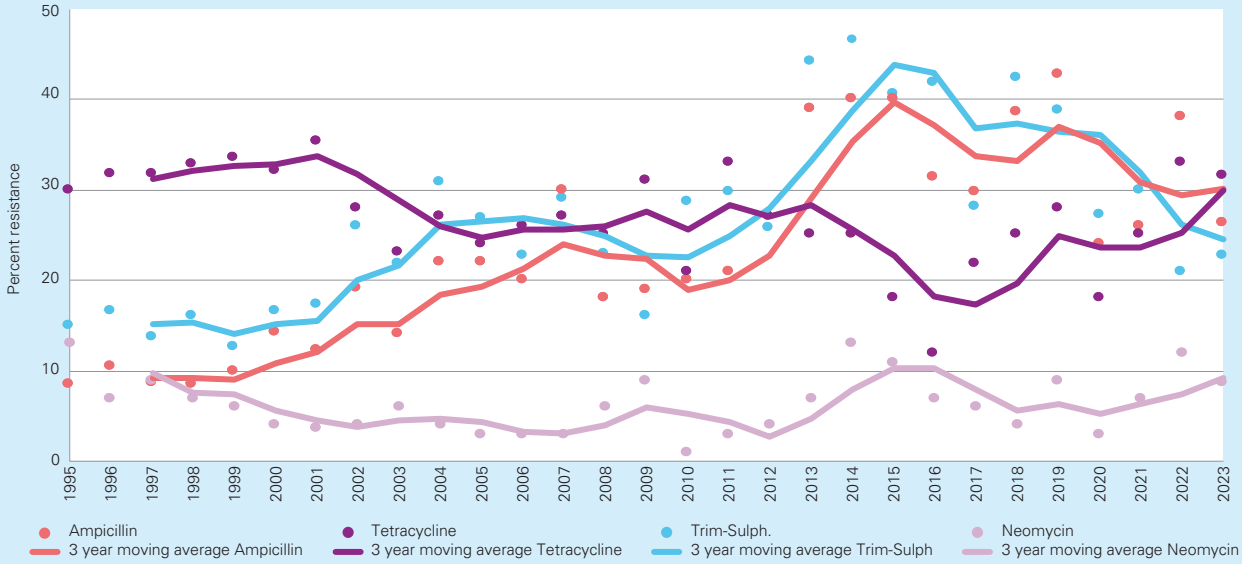


Table 4.10. Distribution of MICs and resistance (%) in enterotoxigenic *Escherichia coli* from pigs 2023.

Antibiotic	Resistance (%) 2023 n=50	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	26						70.0	4.0			26.0	
Cefalexin	0							44.0	54.0		2.0	
Cefotaxime	0			100								
Colistin	0					96.0	4.0					
Enrofloxacin	6		94.0	6.0								
Gentamicin	0						100					
Meropenem	0	100.0										
Neomycin	8							92.0			2.0	6,0
Tetracycline	34						66.0			2.0	32.0	
Trim-sulph.[a]	22				78.0				22.0			

[a]Concentration of trimethoprim is given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

resistance traits. Resistance to ampicillin and to trimethoprim-sulphamethoxazole has increased considerably from 1995 with a peak in 2015-2016 but from 2019 there is a downward trend (Figure 4.4). Resistance to neomycin was comparatively low throughout this period (1995-2023) despite increased sales of veterinary medicinal products aimed at treating post-weaning diarrhoea (see In focus - Sales of antibiotics for group treatment of post-weaning diarrhoea in pigs). Multidrug resistance occurred in 14% (7/50) of the isolates in 2023 and has varied over the years (20% in 2022, 16% in 2021, 11% in 2020, 33% in 2019, 31% in 2018, 20% in 2017). Fifty percent of the isolates were susceptible to all tested antibiotics.

Brachyspira hyodysenteriae

Isolates of *Brachyspira hyodysenteriae* are from clinical submissions of faecal samples. The number of isolates each year varies (n=4-29, 2023 n=4). In routine diagnostics at SVA clinical breakpoints at >2 mg/L for tiamulin and >16 mg/L for tylosin are used. Analysis of antibiotic susceptibility data from isolates of *B. hyodysenteriae* from Sweden 1990-2010 resulted in a proposal for wild type cut-off values (Pringle et al., 2012). In Table 4.11 these cut-off values are used on all data. With the suggested wild type cut-off value >0.25 mg/L for tiamulin, resistance is detected throughout the period. However, during 2016, isolates with MICs above the clinical breakpoint (>2 mg/L) were detected for the first time from Swedish pigs. Therapeutic failure was also observed. Three isolates from 2016 and two from 2017 were classified as clinically resistant. Tylosin resistance has decreased over the years but increased slightly in 2018-2023.

Brachyspira pilosicoli

Isolates of *Brachyspira pilosicoli* are from clinical submissions of faecal samples. ECOFFs for *B. pilosicoli* are not defined for the antibiotics tested. The assessed percentage of resistance using the same wild type cut-off value as for *B. hyodysenteriae* is shown in Table 4.12.

If clinical breakpoints for *Brachyspira hyodysenteriae* are used as guide for the choice of antibiotic for treatment of spirochaetal diarrhoea, 7% are resistant to tiamulin (>2 mg/L).

Resistance to tylosin has decreased from around 2010 but has started to increase in recent years, whereas resistance to tiamulin has remained at a steady level (figure 4.5). However, the number of isolates analysed per year is low.

Figure 4.5. Resistance (%) to tylosin and tiamulin in *Brachyspira pilosicoli* from pigs 2005-2023 with a three-year moving average. The number of isolates per year has varied (n=7-67, 2023 n=38).

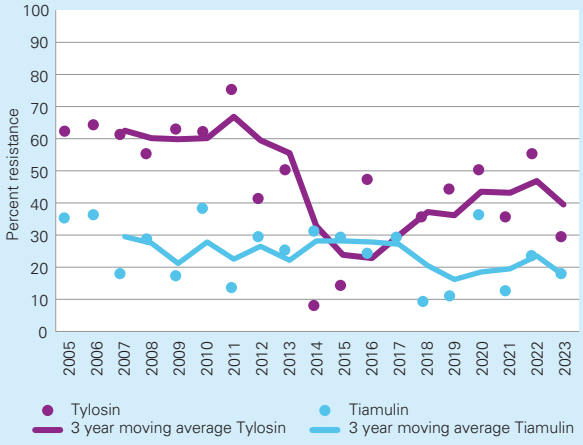


Table 4.11. Resistance (%) in *Brachyspira hyodysenteriae* from pigs 2005-2023 and distribution of MICs for isolates from 2018-2023. Clinical isolates from faecal samples.

Antibiotic	Resistance (%)					Distribution (%) of MICs (mg/L)												
	2005-06 n=54	2007-08 n=38	2009-11 n=40	2012-17 n=55	2018-23 n=42[b]	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	9	3	5	0	0			21.4	61.9	16.7									
Tiamulin	7	18	8	16[a]	10		42.9	9.5	38.1	7.1	2.4								
Tylosin	81	76	60	42	67							9.5	9.5	14.3		2.4	2.4		61.9
Tylvalosin		93	55	51	67				2.4	11.9	19.0	4.8	7.1	26.2	21.4		7.1		
Valnemulin	0	18	3	24	7	47.6	40.5	4.8		4.8		2.4							

[a]Five isolates with MICs above 2 mg/L from a defined outbreak in 2016-2017, [b]Number of isolates 2023 = 4.

Table 4.12. Resistance (%) and distribution of MICs in *Brachyspira pilosicoli* from pigs 2022-2023. Clinical isolates from faecal samples.

Antibiotic	Resistance (%)[a]	Distribution (%) of MICs (mg/L)													
	2022-2023 n=78[b]	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	>128
Doxycycline	5			71.8	17.9	5.1	5.1								
Tiamulin	21		60.3	12.8	6.4	9.0	3.8	1.3	1.3	2.6	2.6				
Tylosin	42							32.1	17.9	6.4	1.3	2.6	5.1	11.5	23.1
Tylvalosin	47				5.1	32.1	15.4	21.8	7.7	3.8	6.4	0.0	7.7		
Valnemulin	19	59.0	14.1	7.7	7.7	7.7	2.6			1.3					

[a]Assessed percentage of resistance using wild type cut-off values for *B. hyodysenteriae,* shown as vertical blue lines, [b]Number of isolates 2023=38.

Actinobacillus pleuropneumoniae

Isolates of *Actinobacillus pleuropneumoniae* are mostly from post-mortem investigations of lungs, but also from cases of arthritis. Data from 2022-2023 and back to 2005 show that the resistance situation is favorable and almost no resistance has been detected to tested antibiotics including penicillin during this period (Table 4.13). Since pneumonia caused by *A. pleuropneumoniae* is an important disease in pig production, sampling and susceptibility testing is desirable if emerging resistance is to be detected early. For treatment of *Actinobacillus pleuropneumoniae* with MICs within the wild type distribution of penicillin (MIC 0.12 – 0.5 mg/L), increased exposure to penicillin is required (Medical Products Agency, 2022). Exposure includes e.g. administration route, dose, and dose interval.

Pasteurella multocida

Clinical isolates of *Pasteurella multocida* are from post-mortem examinations of lungs. The last ten years the number of isolates has decreased to 3-10 isolates per year which is too few for a representative sample to present in a MIC distribution table. All tested isolates have been susceptible to relevant tested antibiotics including penicillin (Table 4.14).

Streptococcus suis

Isolates of *Streptococcus suis* are from post-mortem examination of different organs in diseased pigs from 2013-2018 (n=37) and 2019-2023 (n=72). Resistance to penicillin was rarely found before 2020 (Table 4.15).

Table 4.13. Resistance (%) in *Actinobacillus pleuropneumoniae* and distribution of MICs from pigs 2022-2023.

Antibiotic	Resistance (%) 2022-2023 n=42	Distribution (%) of MICs (mg/L)												
		≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	0			4.8	76.2	19.0								
Doxycycline	0				2.4	9.5	85.7	2.4						
Enrofloxacin	0	2.4	83.3	14.3										
Florfenicol	2							97.6				2.4		
Gamithromycin	0						4.8	7.1	26.2	61.9				
Penicillin	0			2.4	11.9	64.3	21.4							
Tetracycline	0				7.1	38.1	42.9	11.9						
Trim-Sulph.[a]	0		4.8	35.7	57.1	2.4								

[a]Concentration of trimethoprim is given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Table 4.14. Resistance (%) in *Pasteurella multocida* from pigs 2014-2023. Clinical isolates from post-mortem investigations of lungs.

Antibiotic	Cut-off	Number of isolates	% Resistance
Ampicillin[a]	>0.5	36	0
Florfenicol[a]	>1	36	0
Gentamicin	>8	34	0
Penicillin	>0.5	47	0
Tetracyclines[b]	>2 />1[c]	47	0

[a]Between 2014 and first half of 2016, the panel range did not cover today´s ECOFF and has therefore been excluded from the table. [b]Doxycycline was tested 2022-2023, oxytetracycline 2020-2021 and tetracycline 2014-2019 and 2022-2023; [c]ECOFFs for tetracycline and oxytetracycline/ doxycycline.

Table 4.15. Resistance (%) in *Streptococcus suis* from pigs 2013-2018 and 2019-2023, and distribution of MICs from 2019-2023. Samples are from various organs.

Antibiotic	Resistance (%) 2013-2018 n=37	2019-2023 n=72	Distribution (%) of MICs (mg/L)								
			≤0.03	0.06	0.12	0.25	0.5	1	2	4	>8
Clindamycin	11	21					79.2	4.2		16.7	
Enrofloxacin	NR	NR				37.5	59.7	2.8			
Erythromycin	8	6					94.4	1.4	1.4	2.8	
Gentamicin	NR	NR						2.8	34.7	45.8	16.7
Penicillin	3	14	80.6	5.56		4.2	5.6	2.8	1.4		
Tetracycline	65	65				30.6	4.2	2.8	34.7	12.5	15.3
Trim-Sulph.[a]	11	15				84.7	2.8	8.3	1.4	1.4	1.4

NR, not relevant as the genus has inherently low susceptibility to the antibiotic.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Cattle

Escherichia coli from milk samples

Isolates of *E. coli* are from clinical submissions of milk samples from dairy cows. It is likely that most sampled cows had clinical mastitis.

Most of the isolates (89%, 39/44) were susceptible to all antibiotics tested. Resistance to ampicillin (9%) and trimethoprim-sulphamethoxazole (7%) were the most common traits, followed by enrofloxacin (2%) (Table 4.16). No tetracycline resistance was detected in 2023. One isolate (2%) was multiresistant, i.e. resistant to three or more antibiotics (ampicillin, enrofloxacin and trimethoprim-sulphamethoxazole).

Klebsiella pneumoniae from milk samples

Isolates of *Klebsiella pneumoniae* are from clinical submissions of milk samples from dairy cows (Table 4.17). It is likely that most sampled cows had clinical mastitis. Resistance was detected to enrofloxacin and trimethoprim-sulphamethoxazole in one isolate and to tetracycline in one isolate. There is an inherent low susceptibility to ampicillin.

Staphylococcus aureus from milk samples

Isolates of *Staphylococcus aureus* are from clinical submissions of milk samples from dairy cows with clinical mastitis. In 2023, 650 isolates of *S. aureus* were analysed for penicillinase production of which 2.3% (n=15) were positive. Corresponding numbers for 2022 were 3.1% (24/774), 2021 1.2% (7/605), 2020 1.8% (10/551) and 2019 2.8% (15/551).

Table 4.16. Resistance (%) in *Escherichia coli* from dairy cows 2019-2023 and distribution of MICs from 2023. Clinical isolates from milk.

Antibiotic	Resistance (%) 2019 n=74	2020 n=60	2021 n=55	2022 n=46	2023 n=44	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	24	15	18	11	9						45.5	45.5		2.3	6.8	
Cefalexin					0							43.2	52.3	4.5		
Cefotaxime	0	0	0	0	0			100								
Colistin	0	0	0	0	0					100						
Enrofloxacin	3	2	0	7	2		97.7		2.3							
Gentamicin	3	2	0	0	0						100					
Meropenem	NT	0	0	0	0	100										
Neomycin	1	2	4	4	0							97.7	2.3			
Tetracycline	18	7	9	11	0						100					
Trim-sulph.[a]	11	5	20	7	7				93.2			2.3	4.5			

NT, not tested.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole)

Table 4.17. Resistance (%) in *Klebsiella pneumoniae* from dairy cows 2019-2023 and distributions of MICs from 2023. Clinical isolates from milk.

Antibiotic	Resistance (%) 2019 n=34	2020 n=45	2021 n=39	2022 n=35	2023 n=52	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	NR	NR	NR	NR	NR						1.9			30.8	67.3	
Cefotaxime	0	0	0	0	0			100								
Colistin	0	4[b]	0	0	0					100						
Enrofloxacin	6	4	0	0	2		98.1			1.9						
Gentamicin	0	2	0	0	0						100					
Meropenem	NT	0	0	0	0	100										
Neomycin	1	0	0	0	0							100				
Tetracycline	18	11	0	9	2						94.2	3.8			1.9	
Trim-sulph.[a]	11	13	0	0	2				98.1	1.9						

NR, not relevant as the genus has inherently low susceptibility to the antibiotic; NT, not tested.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole); [b]Two isolates with MIC 16 mg/L were negative for *mcr-1* to *mcr-9* genes with PCR. One isolate with MIC 4 mg/L was not available for PCR detection of *mcr* genes.

Pasteurella multocida

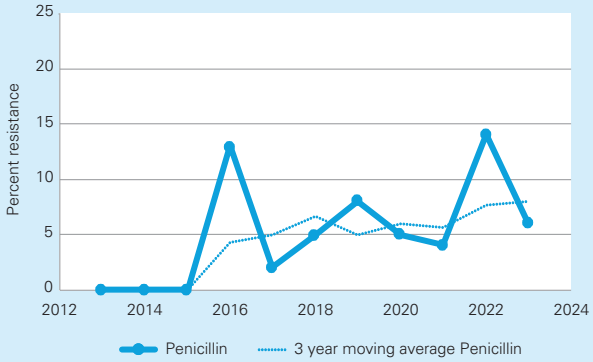
Most isolates of *Pasteurella multocida* are from nasal swabs from calves with respiratory disease or from post-mortem investigations of lungs. Because of a change of panel design, direct comparison with data from earlier years is not possible. For older data see earlier Swedres-Svarm reports.

Antibiotic resistance was generally rare among isolates of *P. multocida* (Table 4.18), but beta-lactamase producing *P. multocida* have been isolated every year since 2016. In 2023, two isolates from the same farm were penicillin resistant and ampicillin resistant. One of these isolates was tested for and showed to produce beta-lactamase. Further, two other isolates were trimethoprim-sulphamethoxazole resistant. Penicillin is considered the first-choice antibiotic for pneumonia in cattle in Sweden. Sampling and susceptibility testing are of importance for early detection of resistance, especially if therapeutic failure is seen.

Mannheimia haemolytica

Most samples of *Mannheimia haemolytica* were from the respiratory tract: from nasal swabs or from post-mortem investigations of lungs from calves with respiratory disease, and a few from other organs: joints, spleen, and navel. Between 2014 and 2023, forty isolates have been susceptibility tested and five of those (years 2015, 2016 and 2019) from three different farms were penicillin resistant (MIC >0,5 mg/L) (table 4.19).

Figure 4.6. Resistance (%) to penicillin in *Pasteurella multocida* from calves 2013-2023 with a three-year moving average. Clinical isolates originating from respiratory tract, isolated from nasal swabs or from post-mortem investigations of lungs. The number of isolates each year varies (n=24-104, 2023=33).



Mycoplasma bovis

Isolates of *Mycoplasma bovis* are from clinical submissions of nasal swabs or post-mortem investigations of lungs from calves with respiratory disease. Published data regarding antibiotic susceptibility of *M. bovis* are scarce and no established breakpoints for either microbiological or clinical resistance are available. Mycoplasmas are intrinsically resistant to beta-lactams due to their lack of a cell wall. For tetracycline and gamithromycin, the MICs were high for 91% and 95% of the

Table 4.18. Distribution of MICs and resistance (%) in *Pasteurella multocida* from calves 2022-2023. Clinical isolates originated from the respiratory tract, isolated from nasal swabs or from post-mortem investigations of lungs.

Antibiotic	Resistance (%) 2022-2023 n=68	Distribution (%) of MICs (mg/L) ≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	10				47.1	42.6			10.3					
Ceftiofur	0				100									
Enrofloxacin	0	86.8	10.3	2.9										
Florfenicol	0							100						
Gamithromycin	2						7.4	29.4	51.5	10.3		1.5		
Penicillin	10		1.5	16.2	69.1	2.9			10.3					
Tetracycline	0				7.4	66.2	26.5							
Trim-sulph.[a]	3		29.4	60.3	7.4				2.9					

[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Table 4.19. Distribution of MICs and resistance (%) in *Mannheimia haemolytica* from calves 2014-2023. Clinical isolates from the respiratory tract, isolated from nasal swabs or from post-mortem investigations of lungs, and a few from joints, spleen, and navel.

Antibiotic	Resistance (%) 2014-2023 n=40	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	>8
Enrofloxacin	0		100							
Florfenicol	0						100			
Penicillin	12		45.0	37.5	5.0	5.0	7.5			
Tetracyclines[a]	0					100				

[a]Tetracycline 2014-2019 and 2022-2023 and oxytetracycline 2020-2021.

Table 4.20. Distribution of MICs in *Mycoplasma bovis* from calves 2020-2023 (n=80). Clinical isolates from the respiratory tract, isolated from nasal swabs or from post-mortem investigations of lungs.

Antibiotic	Distribution (%) of MICs (mg/L)											
	≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Enrofloxacin				1.3	95	3.8							
Florfenicol									7.5	78.8	13.8		
Gamithromycin									1.3	2.5	1.3	95.0	
Penicillin								100					
Tetracycline							2.5	1.3	5	91			

isolates, respectively (table 4.20). For all isolates the florfenicol MICs were higher than the VetCast clinical breakpoints for *Pasteurella multocida* (R > 1 mg/L) and *Mannheimia haemolytica* (R >2 mg/L) (VetCAST, 2019). Enrofloxacin MICs were low for all the tested isolates.

Sheep

Mannheimia haemolytica and *Bibersteinia trehalosi*

Isolates of *Mannheimia haemolytica* are from 2014 to 2023 (n=86) and derive primarily from postmortem investigation of lungs but also from nasal swabs, milk, abscesses, wound secretions and one eye sample. ECOFFs for *M. haemolytica* have been used when available. Resistance to penicillin (MIC >0.5) was detected in two isolates from milk, in one eye sample in 2019 and in one isolate from nasal swab in 2020 (Table 4.21).

Isolates of *Bibersteinia trehalosi* are from the same period as *M. haemolytica* and derive mainly from lung samples. Since there are no ECOFFs for *B. trehalosi*, ECOFFs for *M. haemolytica* were used. One isolate from 2016, two from 2021 and one from 2022, all from lung, were penicillin resistant (Table 4.21).

Table 4.21. Resistance (%) in *Mannheimia haemolytica* and *Bibersteinia trehalosi* from sheep 2014-2023.

Antibiotic	Resistance % *M. haemolytica* (number of isolates)	Resistance % *B. trehalosi* (number of isolates)
Penicillin	5 (86)	10 (41)
Tetracycline[a]	0 (86)	0 (41)
Enrofloxacin	1 (86)	24 (41)
Florfenicol	0 (86)	3 (40)

[a]Doxycycline was tested 2022-2023, oxytetracycline 2020-2021 and tetracycline 2014-2019 and 2022-2023.

Farmed fish

Flavobacterium psychrophilum

Isolates of *Flavobacterium psychrophilum* are from clinical submissions of farmed fish, most of them from outbreaks of disease. More than one isolate can be analysed from the same outbreak. More than one phenotype is detected in more than half of such cases (data not shown). Data from 2018-2023 are compiled and presented as distributions of MICs in Table 4.22. Most isolates are from rainbow trout. Epidemiological cutoffs issued by CLSI are being used (CLSI, 2020b). Resistance to oxolinic acid and oxytetracycline was high in this material whereas no resistance to florfenicol was detected.

In Figure 4.7 resistance to tetracycline and quinolones (nalidixic acid or oxolinic acid) in *F. psychrophilum* 2005-2023 is shown. A three-year moving average is used. There is a marked increase in resistance to these antibiotics over the years despite

Figure 4.7. Resistance (%) in *Flavobacterium psycrophilum* to tetracycline and nalidixic acid/oxolinic acid from farmed fish 2005-2023 with a three-year moving average. No resistance to florfenicol was detected in this period. The number of isolates each year varies (n=8-31, 2022 n=17).

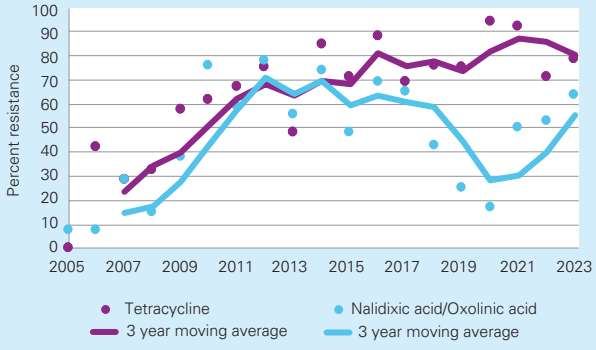


Table 4.22. Distributions of MICs and resistance (%) in *Flavobacterium psychrophilum* from farmed fish 2018-2023. The number of isolates each year varies (n=8-31).

Antibiotic	Resistance (%) 2018-2023 n=90	Distribution (%) of MICs (mg/L)											
		≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	>8
Florfenicol	0					7.8	31.1	43.3	16.7	1.1			
Oxolinic acid	42	1.1			1.1	26.7	28.9	2.2	4.4	35.6			
Oxytetracycline	81			1.1	15.6	2.2	1.1	3.3	3.3	17.8	45.6	10.0	

a limited use up until recently (See Sales of antibiotics for animals). For nalidixic acid/oxolinic acid a downward trend is seen after a peak in 2012, however this downward trend has turned in the latest years. Genome sequencing was used for analysis of a temporally and geographically representative set of *F. psychrophilum* isolates from outbreaks among Swedish farmed salmonid fish. The results indicate repeated nationwide introductions of new clones, presumably by trade of fish and eggs. It is probable that such introductions have contributed to the observed increase in resistance (Söderlund et al., 2018).

Flavobacterium columnare

Isolates of *Flavobacterium columnare* are from clinical submissions of farmed fish. Data from 2018-2023 are compiled and presented as distributions of MICs in Table 4.23. Most isolates of *F. columnare* are from rainbow trout and brown trout. Epidemiological cut-offs issued by CLSI are being used (CLSI, 2020b).

Aeromonas salmonicida var. *salmonicida*

Isolates of *Aeromonas salmonicida* var. *salmonicida* are from clinical submissions of farmed fish. Data from 2019-2023 are compiled and presented as distributions of MICs in Table 4.24. Most isolates are from trout.

Laying hens

Escherichia coli

Isolates of *Escherichia coli* are from laying hens from commercial farms and isolated at post-mortem. Usually more than one hen from the same farm are submitted for examination in disease outbreaks. Compared to 2017-2018 resistance was lower in 2022-2023 for ampicillin and enrofloxacin (Table 4.25).

Table 4.23. Distributions of MICs and resistance (%) in *Flavobacterium columnare* (n=47) from farmed fish 2018-2023.

Antibiotic	Resistance (%) 2018-2023 n=51	Distribution (%) of MICs (mg/L) ≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	>8
Florfenicol	0						12.8	38.3	46.8	2.1			
Oxolinic acid	2		2.1	8.5	36.2	48.9	2.1			2.1			
Oxytetracycline	9			40.4	44.7	2.1	4.3	4.3	2.1			2.1	

Table 4.24. Distributions of MICs and resistance (%) in *Aeromonas salmonicida* var. *salmonicida* from farmed fish 2019-2023. The number of isolates each year varies (n=1-15, 2023 n=2).

Antibiotic	Resistance (%) 2019-2023 n=35	Distribution (%) of MICs (mg/L) ≤0.008	0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	>8
Florfenicol	0						25.7	74.3					
Oxolinic acid	11	2.9	68.6	14.3		2.9	2.9	2.9	5.7				
Oxytetracycline	0			2.9	2.9	25.7	68.6						

Table 4.25. Distributions of MICs 2022-2023 and resistance (%) in *Escherichia coli* from laying hens 2017-2018 and 2022-2023.

Antibiotic	Resistance (%) 2017-2018 n=100	2022-2023 n=86	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	>64
Ampicillin	11	1						52.3	45.3	1.2		1.2	
Cefotaxime	1[b]	0			100								
Colistin	1[c]	0					97.7	2.3					
Enrofloxacin	39	12		88.4	9.3	2.3							
Gentamicin	1	2						97.7	2.3				
Meropenem		0	100										
Neomycin	0	0							100				
Tetracycline	13	16						82.6	1.2			16.3	
Trim-sulph.[a]	3	0				100							

[a]Concentration of trimetoprim given, tested in concentration ratio 1/20 (trimetoprim-sulphamethoxazole); [b]One isolate with MIC >2 mg/L carried bla_{CMY-2} ; [c]one isolate with MIC >8 mg/L was negative for *mcr-1* to *mcr-5* genes with PCR.

SvarmPat – monitoring of resistance in pathogens from farm animals

The SvarmPat programme (Swedish Veterinary Antibiotic Resistance Monitoring – farm animal pathogens) is a project in co-operation between Farm & Animal Health and SVA that started in 2005. It is financed by the Swedish Board of Agriculture.

The purpose of SvarmPat is to reduce emergence and spread of antibiotic resistance in pathogenic bacteria from farm animals, including farmed fish. This is achieved by monitoring and documenting antibiotic resistance in farm animal pathogens, by activities that increase knowledge of antibiotic resistance and prudent use of antibiotics, and by communication of knowledge to practitioners and farmers. Respiratory pathogens from farm animals are generally susceptible to benzylpenicillin, but penicillin resistance is common in *Staphylococcus hyicus* from pigs. Resistance in *Escherichia (E). coli* is most prominent in enteric isolates from young calves and pigs. Susceptibility testing for guidance in antibiotic therapy is warranted, especially for staphylococci, *E. coli*, and *Brachyspira* spp.

Selected studies within SvarmPat

Some of the results regarding resistance in various pathogens are available in Clinical isolates from animals.

Milk samples from dairy cows

Continuous monitoring of resistance in bacteria from clinical mastitis in dairy cows started in 2013. Randomly collected milk samples from dairy cows with clinical mastitis are cultured, isolated bacteria are susceptibility tested, and information about the cow and the herd is registered.

Between 2013 and 2018, samples from cows with clinical mastitis were cultured and 664 isolates susceptibility tested (Duse et al., 2021). The five most common pathogens isolated were *Staphylococcus aureus* (28%), *Streptococcus dysgalactiae* (16%), *Escherichia coli* (15%), *Streptococcus uberis* (11%), and *Trueperella pyogenes* (8%). Most pathogens were susceptible to antibiotics used in Sweden. Resistance to penicillin in *S. aureus* was low (3%), compared to a previous study (7%) from 2002-2003 (Bengtsson et al., 2009). The study also showed that the bacterial panorama was influenced by housing, season, and previous cases of mastitis in the individual cow.

Screening for MRSA in milk samples from dairy cows has been going on since 2010 within the SvarmPat programme. Isolates of beta-lactamase producing *Staphylococcus aureus* from routine submissions to SVA are investigated for methicillin resistance. Between 2013 and 2023, 1439 isolates of anonymous origin have been tested. Within the screening program, MRSA has been confirmed in ten isolates, most recently in 2017.

Anaplasmosis in cattle

A web survey was distributed to veterinarians to assess how common tick-borne fever, anaplasmosis, is in cattle, how the disease is diagnosed, and how it is treated (Persson Waller et al., 2024). Additionally, veterinarians were offered free PCR-analysis of blood samples from suspected cases of Anaplasma infection. The findings from the survey indicate that the occurrence of anaplasmosis remains consistent with levels observed five years ago and is concentrated in the southern region of Sweden. The most common treatment was a combination of tetracycline and NSAID. Among 187 samples tested, *Anaplasma (A) phagocytophilum* was identified in 77 cases (41%), while *A. marginale* was not detected. Thus, most samples were negative. There was no correlation between the symptoms stated on the lab order form and positive test result, which emphasizes the risk of unnecessary antibiotic treatment when diagnosis is based solely on clinical examination.

Evaluation of alternative treatment methods for hoof diseases

Foot rot and digital dermatitis are infectious claw diseases affecting cattle, causing lameness. In a study, treatment methods currently used were investigated by analysing hoof trimming records, as well as assessing the changes in treatments over the past ten years through a questionnaire sent to dairy farmers and claw trimmers (Andersson 2023). Historically, antibiotics were recommended for both diseases, but the study results consistently indicate that antibiotic treatment has decreased. Farmers and hoof trimmers now prefer alternative treatments like salicylic acid bandages, in line with treatment recommendations. Also, there is an increased use of NSAIDs when treating foot rot.

Respiratory tract samples from calves

One of the most common infections in calves is pneumonia caused by *Pasteurella multocida*, for which penicillin is considered the first-choice antibiotic in Sweden. However, since beta-lactamase producing *P. multocida* isolates have been isolated every year since 2016, sampling and susceptibility testing is important, especially if therapeutic failure is seen in a herd. Diagnostics using PCR are increasingly used to detect respiratory pathogens. Within SvarmPat, respiratory samples from calves that are PCR-positive for *P. multocida*, *Mannheimia haemolytica* or *Histophilus somni*, are being cultured, to obtain isolates for susceptibility testing.

Mycoplasma bovis - few treatment options

In SvarmPat samples from calves PCR-positive for *Mycoplasma bovis* have been cultured and obtained isolates susceptibility tested. MICs were high for most antibiotics available for treatments, except for enrofloxacin

(Backhans et al., 2022). Standardized methods and clinical breakpoints are lacking, however, using sequencing, preliminary data show that the clone that is dominant in Swedish herds has mutations in ribosomal RNA that cause resistance to macrolides and tetracyclines. Overall, the results indicate that the treatment options for infections with *M. bovis* are few.

Respiratory tract samples from pigs

The important respiratory pathogens *Actinobacillus pleuropneumoniae* and *Pasteurella multocida* isolated from pigs are continuously susceptibility tested within SvarmPat. Resistance to penicillin in these bacteria is uncommon, supporting the recommendation to primarily use penicillin for treatment of pneumonia in pigs.

Streptococcus suis

Streptococcus suis is one of the most important pathogens in pigs. Penicillin is the primary choice of treatment but in recent years an increasing occurrence of penicillin resistance has been seen. In the years 2018-2021, 17% of *S. suis* were resistant using the clinical breakpoint >0,12 mg/L (Backhans & Pringle, 2022). Diagnostics and susceptibility testing should be performed when infection with *S. suis* is suspected. In case of longer treatment in a pig herd, sampling and testing should be repeated.

Enteric samples from pigs

Escherichia coli

Resistance to ampicillin and trimethoprim-sulphamethoxazole in *Escherichia coli* isolated from piglets with diarrhoea has been increasing over the years but stabilized around 2015. This emphasizes the importance of susceptibility testing in herds with neonatal and post-weaning diarrhoea.

Brachyspira hyodysenteriae

Swine dysentery is a severe disease in pigs, with a few cases each year in Sweden. In Sweden there is active monitoring of swine dysentery in nucleus and multiplying herds since the 1990s. Furthermore, a network with the goal of eradicating the disease from Swedish pig herds formed in 2019. The resistance situation in the causative agent *B. hyodysenteriae* is favourable compared to many other countries, but clinical resistance to tiamulin in *B. hyodysenteriae* was detected for the first time 2016 in an outbreak in several herds. Within SvarmPat whole genome sequencing was used, and it confirmed that the outbreak was caused by the same clone. After successful eradication in affected herds, no isolates with tiamulin-MICs >2 mg/L have been detected since 2018.

Brachyspira pilosicoli

Spirochaetal diarrhoea is a less severe but more common disease than swine dysentery. Cases with treatment failure have been reported, but breakpoints for antibiotic resistance specific for *B. pilosicoli* are lacking.

Acute clinical mastitis in ewes

Between March 2022 and August 2023, 53 milk samples from ewes with acute clinical mastitis from 33 herds were cultured for bacteria, and susceptibility testing was performed on the isolates. *Staphylococcus aureus* was the most common bacterium followed by *Mannheimia haemolytica*. *Escherichia coli* was not found in any of the samples, which differs from the results of the latest survey conducted in 2007. All *S. aureus* were penicillin-sensitive, while two *Mannheimia* isolates were penicillin-resistant. The study indicates a shift in mastitis pathogens, with *E. coli* becoming less common. The recommendation remains that benzylpenicillin should be the first-line choice for acute clinical mastitis in ewes. Continued monitoring of pathogens and resistance patterns is important, particularly in cases of treatment failure.

Bacteria from farmed fish

In case of outbreaks of disease caused by pathogenic bacteria among farmed fish, up to five isolates from each outbreak are susceptibility tested within SvarmPat. Bacterial species vary depending on the fish species. In 2022 isolates of *Flavobacterium psychrophilum*, *Flavobacterium columnare*, atypical *Aeromonas salmonicida*, *Aeromonas salmonicida* var. *salmonicida*, *Aeromonas hydrophila*, *Aeromonas sobria*, *Aeromonas spp.*, *Yersinia ruckeri*, *Vibrio anguillarum*, and *Lactobacillus* species were susceptibility tested. In the most commonly isolated bacteria, *F. psychrophilum*, resistance to oxolinic acid and tetracycline was high but no resistance to florfenicol was detected. In the other bacteria from farmed fish, resistance was uncommon.

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Horses

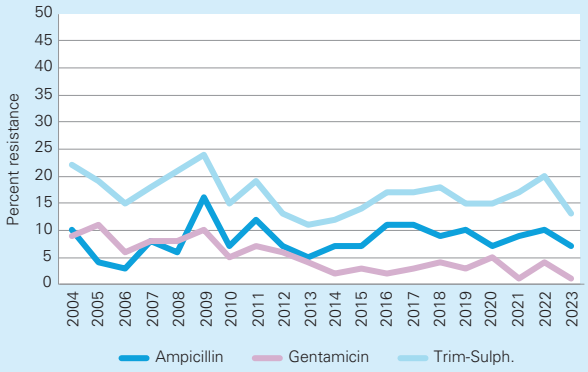
Escherichia coli

Isolates of *Escherichia coli* are from clinical submissions of samples from the genital tract of mares. As in previous years, resistance to trimethoprim-sulphamethoxazole was the most common trait in 2023 (Figure 4.8 and Table 4.26). Occurrence of resistance to gentamicin is continuously low, from 2013 and onwards ≤5% (Figure 4.8). However, this resistance has varied somewhat over the years and trends are difficult to estimate.

Eighty-two percent (209/255) of the isolates were susceptible to all the tested antibiotics. The proportion of multiresistance was 2% (5/255). Two of the five multiresistant isolates were resistant to four antibiotics and three isolates to three antibiotics. The most common phenotype was resistance to ampicillin, tetracycline and trimethoprim-sulphamethoxazole. Both of the two isolates resistant to four antibiotics had a common phenotype with resistance to gentamicin in addition to ampicillin, tetracycline, and trimethoprim-sulphamethoxazole. For comparison of resistance in *E. coli* of different origin see "Comparative analysis".

One of the isolates was resistant to cefotaxime, but none were resistant to colistin or meropenem. The one isolate resistant to cefotaxime (MIC >0.25mg/L) was available for further testing but genes conferring transferable ESC resistance were not detected.

Figure 4.8. Resistance (%) in clinical isolates of *Escherichia coli* from horses 2004-2023. Isolates are from clinical sampling of the genital tract of mares. The number of isolates each year varies (n=124-324, 2023 n=255).



Streptococcus equi ssp. *zooepidemicus*

Isolates of *Streptococcus equi* ssp. *zooepidemicus* are from clinical submissions, and mainly from the respiratory tract (61%) of horses. Over the years, most of the isolates (96% in 2023) have been susceptible to all relevant tested antibiotics. In 2023, only resistance to clindamycin and trimethoprim-sulphamethoxazole was detected. The proportion of resistance has varied over the years, for clindamycin between 2 and 11% in 2015-2023 and for trimethoprim-sulphamethoxazole there

Table 4.26. Distribution of MICs and resistance (%) in *Escherichia coli* from horses, 2023. Clinical isolates from the genital tract of mares.

Antibiotic	Resistance (%) 2023 n=255	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	>32
Ampicillin	7						40.4	49.0	3.5		7.1	
Cefotaxime	<1			99.6	0.4							
Colistin	0					99.6	0.4					
Enrofloxacin	0		100									
Gentamicin	1						98.8	0.4		0.8		
Meropenem	0	100										
Neomycin	0							99.6	0.4			
Tetracycline	6						93.3	0.8			5.9	
Trim-Sulph.[a]	13				87.1	1.2			11.8			

[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole).

Table 4.27. Distribution of MICs and resistance (%) in *Streptococcus equi* ssp. *zooepidemicus* isolated from horses, 2023. Clinical isolates mainly from the respiratory tract.

Antibiotic	Resistance (%) 2023 n=89	Distribution (%) of MICs (mg/L) ≤0.03	0.06	0.12	0.25	0.5	1	2	4	>4
Cephalotin	0						100			
Clindamycin	2					97.8	2.2			
Erythromycin	0					100				
Gentamicin	NR							2.2	1.1	96.6
Penicillin	0	100								
Tetracycline	NR				2.2		7.9	43.8	40.4	5.6
Trim-Sulph.[a]	2				97.8		1.1	1.1		

NR, not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

was an increase in resistance from 7 to 18% in 2015-2018, but from 2018 to 2023 a decline to 2% (Table 4.27 and previous Swedres-Svarm reports). None of the isolates was resistant to penicillin. The number of isolates is low and varies each year (n=43-102, and in 2023 n=89) which could somewhat cause minor variations between years.

Streptococcus equi ssp. *zooepidemicus* has a low inherent susceptibility to aminoglycosides (e.g. gentamicin) and tetracyclines.

Staphylococcus aureus

Isolates of *Staphylococcus aureus* are from clinical submissions of samples from skin lesions, excluding wounds and abscesses, from horses.

Resistance to penicillin due to penicillinase production is still the most common trait (23%). The proportions of resistance to gentamicin, tetracycline and trimethoprim-sulphamethoxazole have differed slightly over the years and trends are difficult to estimate (Figure 4.9). Resistance to fusidic acid among the tested isolates has varied since 2017, from 5 to 17% and was in 2022 11% but decreased to 4% in 2023 (Table 4.28 and previous Swedres-Svarm reports).

Sixty-three percent (79/125) were susceptible to all the tested antibiotics. Three isolates (2%) were resistant to three or more of the tested antibiotics (i.e. multiresistant), which is comparable to the figures in 2015-2022 (0-5%) (see previous Swedres-Svarm reports).

One isolate was resistant to cefoxitin (MIC >4 mg/L) and was positive when tested with PCR for detection of the *mecA* gene. For more information on MRSA isolated from horses in Sweden, see "Notifiable diseases, Methicillin-resistant *Staphylococcus aureus* (MRSA)".

Figure 4.9. Resistance (%) in clinical isolates of *Staphylococcus aureus* 2008-2023 from skin of horses. Figure for trimethoprim-sulphamethoxazole 2015-2023.The number of isolates each year varies (n=75-145, 2023 n=125).

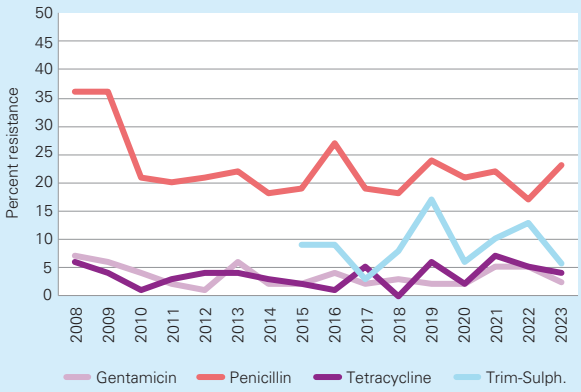


Table 4.28. Distribution of MICs and resistance (%) in *Staphylococcus aureus* isolated from horses, 2023. Clinical isolates from the skin.

Antibiotic	Resistance (%) 2023 n=125	Distribution (%) of MICs (mg/L)												
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cefoxitin	<1[a]					0.8		11.2	87.2	0.8				
Cephalotin	3						96.8	3.2						
Clindamycin	2					97.6	2.4							
Enrofloxacin	0				93.6	6.4								
Erythromycin	2					97.6	0.8		1.6					
Fusidic acid	4					96.0	3.2	0.8						
Gentamicin	2						93.6	4.0	1.6	0.8				
Nitrofurantoin	0										94.4	5.6		
Penicillin	23[b]	76.0	3.2	0.8		0.8	2.4	16.8						
Tetracycline	4				83.2	11.2	1.6	2.4		1.6				
Trim-Sulph.[c]	6				94.4	5.6								

[a]The one isolate resistant to cefoxitin (MIC >4 mg/L) was tested with PCR for the *mecA* and *mecC* genes and found positive for *mecA*; [b]Denotes beta-lactamase production; [c]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Actinobacillus

Isolates of *Actinobacillus* spp. are from clinical submissions of samples from various anatomical sites, of which the most common are wounds (34%) and respiratory tract (20%). Thirteen percent of the samples are from abscesses.

For *Actinobacillus* spp. isolated from horses, ECOFFs for *A. pleuropneumoniae* have been used regarding penicillin, tetracycline and trimethoprim-sulphamethoxazole. For other antibiotics clinical breakpoints have been applied (Table 4.29).

Out of the 14 isolates with MIC >0.25 mg/L for penicillin, all but two have been tested for penicillinase production. All tested isolates with MIC 0.5 mg/L were negative, while tested isolates with MIC ≥1 varied in penicillinase production.

For treatment the *Actinobacillus* spp. wild type distribution of penicillin (MIC 0.03 - 1 mg/L) requires increased exposure to penicillin (Medical Products Agency, 2015). Exposure includes e.g. administration route, dose, and dose interval.

Table 4.29. Distribution of MICs and resistance (%) in *Actinobacillus* spp. from horses, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=89	Distribution (%) of MICs (mg/L) ≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	>4
Enrofloxacin	1	79.8	13.5	4.5	1.1		1.1				
Gentamicin	NR							23.6	32.6	38.2	5.6
Penicillin	3		10.1	10.1	24.7	39.3	9.0	3.4	3.4		
Tetracycline	0				12.4	43.8	36.0	6.7	1.1		
Trim-Sulph.[a]	1		75.3	15.7	5.6	2.2		1.1			

NR, not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole).

Dogs

Escherichia coli

Isolates of *Escherichia coli* are from clinical submissions of urine from dogs, submitted either as urine, swab dipped in urine or cultures from dip-slides or other agar plates. As in previous years, resistance to ampicillin was the most common trait in 2023, 12% (Figure 4.10 and Table 4.30). Although the proportion of resistance in the tested isolates has varied somewhat between 2005 and 2023 there is still a slight decline in resistance for the four antibiotics ampicillin, enrofloxacin, nitrofurantoin and trimethoprim-sulphamethoxazole (Figure 4.10).

Eighty-four percent (754/902) of the isolates were susceptible to all the tested antibiotics, and the proportion of multiresistance was 3% (31/902). Seventy seven percent (24/31) of the multiresistant isolates were resistant to three antibiotics, 13% (4/31) to four, and 6% (2/31) to five antibiotics. One (3%) of the isolates was resistant to six of the tested antibiotics. For comparison of resistance in *E. coli* of different origin see "Comparative analysis".

The most common phenotype, resistance to ampicillin, tetracycline and trimethoprim-sulphamethoxazole, was detected in 26% (8/31) of the multiresistant isolates. Of the seven isolates resistant to four or more antibiotics, four had this phenotype.

Fifteen (2%) of the *E. coli* isolates were resistant to cefotaxime (MIC >0.25mg/L), and all were available for further testing. Genes conferring transferable ESC resistance were detected in six of the isolates. Two carried the gene $bla_{\text{CTX-M-15}}$, one carried $bla_{\text{CTX-M-3}}$, one carried $bla_{\text{CTX-M-27}}$ and two carried $bla_{\text{CMY-2}}$. For more information about ESBL-producing Enterobacterales isolated from dogs in Sweden, see "Notifiable diseases" ESBL-producing Enterobacterales. None of the isolates were resistant to meropenem (MIC >0.12mg/L). Three of the isolates were resistant to colistin (MIC >2mg/L). All three isolates were available for PCR analysis of the *mcr-1* to *mcr-9* genes, and all were negative.

Figure 4.10. Resistance (%) in clinical isolates of *Escherichia coli* from dog urine 2005-2023. The number of isolates each year varies (n=304-1162, 2023 n=902).

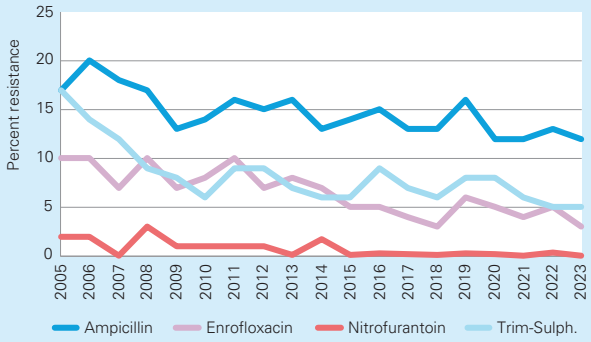


Table 4.30. Distribution of MICs and resistance (%) in *Escherichia coli* from dogs, 2023. Clinical isolates from urine.

Antibiotic	Resistance (%) 2023 n=902	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin	12						49.0	36.9	2.2	0.3	11.5		
Cefalexin	2							12.0	79.9	6.0	0.6	1.6	
Cefotaxime	2[b]			98.2	0.8	0.1	0.2	0.7					
Colistin	<1[c]					99.2	0.4	0.1	0.1	0.1			
Enrofloxacin	3		96.9	1.1	1.4				0.6				
Gentamicin	1						99.0	0.2		0.1	0.7		
Meropenem	0	100											
Neomycin	<1							98.6	0.6	0.2	0.2	0.4	
Nitrofurantoin	0										99.8	0.2	
Tetracycline	4						95.1	0.8		0.2	3.9		
Trim-Sulph.[a]	5				94.8	0.7	0.6	0.1	3.9				

[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole); [b]All isolates (n=16) with MIC >0.25 mg/L were available for verification. Genes conferring transferable ESC resistance were detected in six of them; [c]All isolates (n=3) with MIC >2mg/L were available for PCR detection of the *mcr-1* to *mcr-9* genes, and all were negative.

Staphylococcus pseudintermedius

Isolates of *Staphylococcus pseudintermedius* are from clinical submissions of samples from dogs. Until 2017, only resistance of *S. pseudintermedius* isolated from clinical submissions of sample from skin lesions in dogs were reported (see previous Swedres-Svarm reports). From 2017 and onwards three different sample collection sites have been compared, namely skin lesions (S1), wounds (S2) and external ear (S3) (see Table 4.31 and previous Swedres-Svarm reports).

Resistance to penicillin due to penicillinase production is high for all three sample collections (S1: 69%, S2: 75% and S3: 72% Table 4.31), compared to other staphylococci in companion animals (Table 4.28, table 4.32 and table 4.36). Although still high, the proportion of resistance to penicillin for isolates from skin lesions has declined from 90% in 2009 to 69% in 2023. Compared to penicillin, resistance to clindamycin and tetracycline remains at lower levels, and has also declined since 2007 (see previous Swedres-Svarm reports). The proportion of resistance to fusidic acid is not comparable before 2015, due to a change in the tested range of concentrations and cut off but has, since 2015, declined (Table 4.31 and Figure 4.11). Compared to other staphylococci isolated from companion animals, the proportion of resistance is high in the tested isolates. Only 26% (121/462) in sample collection skin (S1), 20% (148/748) in collection wounds (S2) and 22% (72/328) in collection ear (S3) were susceptible to all the tested antibiotics.

The proportion of multiresistance for the S1 isolates was 20% (92/462), S2: 18% (132/748) and S3: 18% (58/328). This could be compared to 4% multiresistance in *S. schleiferi* isolated from dogs and 2% in *S. aureus* from horses and 5% in *S. felis* from cats. Fifty-five percent (51/92) of the multiresistant S1 isolates were resistant to three antibiotics; 30% (28/92) to four; 5% (5/92) to five; 5% (5/92) to six and 2% (2/92) to seven antibiotics. One isolate was resistant to nine antibiotics. The proportion of isolates resistant to five or more antibiotics has declined over the recent years. In 2016 almost one-third of the multiresistant isolates were resistant to five or more antibiotics, compared to 15-22% in 2017-2021, 15% (14/93) in 2022 and 14% (13/92) in 2023. Of the multiresistant isolates, resistance to penicillin, clindamycin and erythromycin was the most common phenotype for all three sample collections, S1: 84% (77/92), S2: 64% (84/132) and S3: 55% (32/58).

Three of the S1 isolates, eight S2 and one S3 isolate were resistant to oxacillin (MIC >0.25 mg/L). All twelve isolates were tested with PCR for detection of the *mecA* and *mecC* genes and were all positive except one isolate in the S1-group which was negative. For more information on MRSP isolated from dogs in Sweden, see "Notifiable diseases", Methicillin-resistant *Staphylococcus pseudintermedius* (MRSP).

Figure 4.11. Resistance (%) in *Staphylococcus pseudintermedius* from dogs, 2007-2023. Figures for fusidic acid 2015-2023. Clinical isolates from skin (S1). The number of isolates each year varies (n=220-567, 2023 n=462).

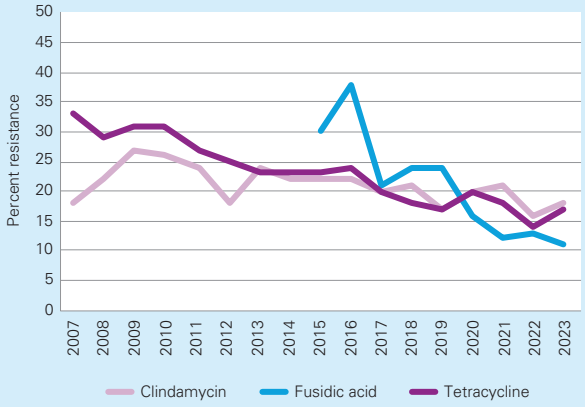


Table 4.31. Distribution of MICs and resistance (%) in *Staphylococcus pseudintermedius* from dogs 2023. Clinical isolates from skin (S1), wounds (S2) and external ear (S3).

Antibiotic	Resistance (%)			Distribution (%) of MICs (mg/L), isolates from skin (S1)												
	2023 n=328 S3	2023 n=748 S2	2023 n=462 S1	≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalothin	1	<1	<1						99.6		0.4					
Cefoxitin[a]							58.0	40.5	0.9		0.6					
Clindamycin	12	12	18					82.3	0.9	0.4	16.5					
Enrofloxacin	2	1	1				95.7	3.2	0.2	0.9						
Erythromycin	16	15	20					79.7	1.1	0.2	19.0					
Fusidic acid	13	10	11					89.0	1.7	0.2	9.1					
Gentamicin	6	3	5						95.5	1.5	0.9	2.2				
Nitrofurantoin	<1	<1	0										99.6	0.4		
Oxacillin	<1[c]	1[c]	<1[c]				99.4		0.2	0.4						
Penicillin	72[d]	75[d]	69[d]	32.3	7.6	6.7	15.6	12.8	6.5	18.6						
Tetracycline	20	17	17				80.5	1.5	0.9			17.1				
Trim-Sulph.[b]	5	6	5				66.5	28.4	1.7	0.4	0.6	2.4				

[a]No cut-off available for *S. pseudintermedius;* [b]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole); [c]The twelve isolates with MIC>0.25 for oxacillin were tested with PCR for detection of the *mecA* and *mecC* genes, eleven were positive and one was negative; [d]Denotes beta-lactamase production.

Staphylococcus schleiferi/coagulans

Isolates of *Staphylococcus schleiferi/coagulans* are from clinical submissions of samples from various anatomical sites in dogs, but mainly from the external ear canal (44%) or skin (27%). The isolates were species identified with MALDI-TOF MS, *S. schleiferi* and *S. coagulans* cannot be separated by this method.

The proportion of resistance in isolates of *S. schleiferi* (Table 4.32) was low for most antibiotics compared to isolates of the more common staphylococcus, *S. pseudintermedius* (Table 4.31), isolated from dogs. The proportion of penicillinase producing isolates among the tested *S. schleiferi* isolates was 6%, which is low compared to other *Staphylococcus* spp. from animals, and comparable to figures in 2014-2022 (<1-4%) (see previous Swedres-Svarm reports). Resistance to enrofloxacin is high compared to other staphylococci presented in Swedres-Svarm, although the figure has declined, from 20% in 2016 to 8% in 2023. For the other tested antibiotics there is no major difference between years (see Table 4.32 and previous Swedres-Svarm reports).

Sixty-seven percent (108/161) of the *S. schleiferi* isolates were susceptible to all the tested antibiotics. This is a negative trend, as 81% of the isolates were susceptible to all tested antibiotics in 2018 and since then the figures have gradually declined. Multiresistance was detected in 4% (7/161) of the isolates and is comparable to figures in 2018-2022 (1-7%). Of the seven multiresistant isolates, five were resistant to three of the tested antibiotics, none was resistant to four but two isolates were resistant to five antibiotics. All of the multiresistant isolates were resistant to clindamycin and six were resistant to erythromycin. No other specific phenotype was noticed.

Pseudomonas aeruginosa

Isolates of *Pseudomonas aeruginosa* are from clinical submissions of samples from the external ear canal in dogs. *Pseudomonas aeruginosa* is inherently resistant to trimethoprim-sulphonamides, tetracyclines and aminopenicillins (including combinations with clavulanic acid). The isolates of *P. aeruginosa* were prior to 2014 tested for polymyxin B susceptibility and all tested isolates have been sensitive throughout the years (see previous Swedres-Svarm reports). In 2014, polymyxin B was replaced by the equivalent antibiotic colistin and since then, 0-1% of the isolates have been resistant to colistin. The proportion of resistance to enrofloxacin has gradually declined from 25% in 2009 to 5% in 2023. The figures for gentamicin have stabilized at ≤1-2% over the recent years (see Table 4.33 and previous Swedres-Svarm reports). None of the isolates were resistant to more than one of the tested antibiotics.

Table 4.32. Distribution of MICs and resistance (%) in *Staphylococcus schleiferi* from dogs, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=161	Distribution (%) of MICs (mg/L)												
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalothin	0						100							
Cefoxitin[a]	NA				22.4	76.4	0.6	0.6						
Clindamycin	6					93.8	0.6	1.2	4.3					
Enrofloxacin	8				87.0	5.0	5.6	2.5						
Erythromycin	6					93.8	1.2	0.6	4.3					
Fusidic acid	17					82.6	7.5	4.3	5.6					
Gentamicin	2						97.5	1.9		0.6				
Nitrofurantoin	<1										99.4		0.6	
Oxacillin	0				97.5	1.9	0.6							
Penicillin[b]	6	94.4	1.9	0.6	1.2	1.2		0.6						
Tetracycline	2				96.9		0.6		0.6	1.9				
Trim-Sulph.[c]	0				98.1	1.9								

NA, not appicable.
[a]No cut-off available for *S. schleiferi;* [b]Denotes beta-lactamase production; [c]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Table 4.33. Distribution of MICs and resistance (%) in *Pseudomonas aeruginosa* from dogs, 2023. Clinical isolates from the external ear canal.

Antibiotic	Resistance (%) 2023 n=151	Distribution (%) of MICs (mg/L)								
		≤0.12	0.25	0.5	1	2	4	8	16	>16
Enrofloxacin	5	3.3	6.0	40.4	37.1	7.9	0.7	4.6		
Colistin[a]	<1				80.1	15.2	4.0	0.7		
Gentamicin	1					82.8	15.2	0.7	1.3	

[a]Colistin is equivalent to polymyxin B.

Pasteurella canis/oralis

Isolates of *Pasteurella* spp. are from clinical submissions of samples from various anatomical sites from dogs, mainly wounds (57%), abscesses (11%), and skin and external ear canal (14%).

Pasteurella canis/oralis was the most common *Pasteurella* sp. isolated in samples from dogs, 85% (289/341). The isolates were species identified with MALDI-TOF MS and *P. canis* and *P. oralis* cannot be separated by the method.

The cut-off for *Pasteurella multocida* has been applied for all *Pasteurella* spp. If not including gentamicin, 96% (253/263) of the isolates were susceptible to all antibiotics tested. *Pasteurella* spp. have a low inherent susceptibility to aminoglycosides, e.g. gentamicin.

The proportion of resistance to enrofloxacin is generally low, with variations between <1% (2014), 4% (2020) and 3% (2023). Resistance to trimethoprim-sulphamethoxazole has been detected in one isolate each year 2020-2021, in 2022 it was detected in two isolates and in seven isolates 2023 (Table 4.34 and previous Swedres-Svarm reports). Before 2020, all tested isolates were susceptible to trimethoprim-sulphamethoxazole (see previous Swedres-Svarm reports). Out of ten resistant isolates, four were resistant to both enrofloxacin and trimethoprim-sulphamethoxazole, the other six were resistant to either enrofloxacin or trimethoprim-sulphamethoxazole.

Table 4.34. Distribution of MICs and resistance (%) in *Pasteurella canis/oralis* from dogs, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=263	Distribution (%) of MICs (mg/L) ≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	>4
Ampicillin	0			89.4	7.6	3.0					
Enrofloxacin	3	94.3	3.0		1.1	0.4	0.8	0.4			
Gentamicin	NR							93.9	3.4	2.7	
Penicillin	0		70.0	26.2	3.8						
Tetracycline	0				32.3	64.3	3.4				
Trim-Sulph.[a]	3		95.4	1.1	0.8	1.1	1.1		0.4		

NR, not relevant as *Pasteurella* spp. have a low inherent susceptibility to aminoglycosides, as gentamicin.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole).

Cats

Escherichia coli

Isolates are from clinical sampling of urine, submitted either as urine or cultures from dip-slides or other agar plates. As in previous years, and in *Escherichia coli* isolated from urine in dogs (Table 4.30), resistance to ampicillin was the most common trait in 2023 (Table 4.35 and Figure 4.12). In comparison, in *E. coli* isolated from the genital tract of horses (mares) resistance to trimethoprim-sulphamethoxazole was most common (Table 4.26 and Figure 4.8). The proportions of resistance in the *E. coli* isolated from cat urine have differed somewhat throughout the years and trends are difficult to estimate (Figure 4.12).

Figure 4.12. Resistance (%) in clinical isolates of *Escherichia coli* from urine of cats, 2007-2023. The number of isolates each year varies (n=131-545, 2023 n=492).

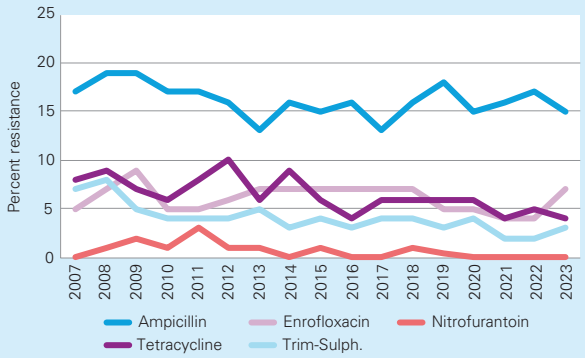


Table 4.35. Distribution of MICs and resistance (%) in *Escherichia coli* isolated from cats, 2023. Clinical isolates from urine.

Antibiotic	Resistance (%) 2023 n=492	Distribution (%) of MICs (mg/L) ≤0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Ampicillin	15						61.2	23.2	0.4		15.2		
Cefalexin	2							24.6	69.1	4.7		1.6	
Cefotaxime	2[b]			98.4	1.2	0.2		0.2					
Colistin	<1[c]					99.0	0.8		0.2				
Enrofloxacin	7		93.5	4.7	0.6				1.2				
Gentamicin	<1						99.4				0.6		
Meropenem	0	99.8	0.2										
Neomycin	<1							99.4	0.2		0.2	0.2	
Nitrofurantoin	0										99.8	0.2	
Tetracycline	4						95.1	0.6			4.3		
Trim-Sulph.[a]	3				97.0	0.4	0.2		2.4				

[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole); [b]Eight isolates with MIC >0.25mg/L were available for verification. Genes conferring transferable ESC resistance were detected in one of the isolates; [c]The one isolate with MIC >2mg/L was available for PCR detection of the *mcr-1* to *mcr-9* genes and the isolate was negative.

Seventy-eight percent (382/492) of the *E. coli* isolates were susceptible to all the tested antibiotics. The proportion of multiresistance was 4% (19/492). Eighteen of the nineteen multiresistant isolates were resistant to three antibiotics and one to four antibiotics. No specific phenotype was noticed. For comparison of resistance in *E. coli* of different origin see "Comparative analysis".

Eight of the *E. coli* isolates were resistant to cefotaxime (MIC >0.25 mg/L). Genes conferring transferable ESC resistance were detected in one of the isolates (bla_{CMY-2}). For more information on ESBL isolated from cats in Sweden, see Notifiable diseases, ESBL-producing Enterobacterales. One isolate was resistant to colistin (MIC >2mg/L) but found negative in PCR analysis of the *mcr-1* to *mcr-9* genes.

Staphylococcus felis

Isolates of *Staphylococcus felis* are from clinical submissions of samples from various anatomical sites, mainly abscesses and wounds (33%), the external ear canal (24%) and urine (24%) in cats.

The proportions of resistance to the tested antibiotics in isolates of *S. felis* (Table 4.36) were, as in previous years, lower than for *S. pseudintermedius* in dogs (Table 4.31 and previous Swedres-Svarm reports). Resistance to penicillin due to penicillinase production was 17% in *S. felis*, compared to 69-75% (three different sample collections) in *S. pseudintermedius* in dogs.

Seventy-three percent (194/266) of the *S. felis* isolates were susceptible to all the tested antibiotics. The proportion of multiresistance has varied between <1-7% during 2015-2022 (see previous Swedres-Svarm reports). In 2023, multiresistance was detected in 5% (13/266) of the isolates. The most common phenotype was resistance to penicillin, clindamycin and erythromycin (12/13).

Pasteurella multocida

Isolates of *Pasteurella* spp. are from clinical submissions of samples from various anatomical sites, but mainly from wounds or skin lesions, abscesses, and the external ear canal (79%) in cats.

Pasteurella multocida was the most common *Pasteurella* sp. isolated in samples from cats, 91%. The proportion of resistance was low in the tested isolates (Table 4.37) and no resistance to penicillin was detected. *Pasteurella* spp. have a low inherent susceptibility to aminoglycosides, e.g. gentamicin.

Table 4.36. Distribution of MICs and resistance (%) in *Staphylococcus felis* from cats, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=266	Distribution (%) of MICs (mg/L)												
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalothin	0						100							
Cefoxitin[a]	NA				94.7	2.6	1.5	0.8	0.4					
Clindamycin	7					93.2	1.1	0.4	5.3					
Enrofloxacin	1				95.9	3.0	0.8	0.4						
Erythromycin	11					89.5	1.9		8.6					
Fusidic acid	4					96.2	3.3	0.8						
Gentamicin	2						98.5	0.8	0.8					
Nitrofurantoin	0										98.9	1.1		
Oxacillin	0				100									
Penicillin	17[c]	81.3	1.1	2.3	2.3	4.9	1.9	4.5						
Tetracycline	2				95.1	2.6	0.4			1.9				
Trim-Sulph.[b]	<1				97.7	1.5	0.8							

NA, not applicable.
[a]No cut-off available for S. felis; [b]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole); [c]Denotes beta-lactamase production.

Table 4.37. Distribution of MICs and resistance (%) in *Pasteurella multocida* from cats, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=380	Distribution (%) of MICs (mg/L)									
		≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	>4
Ampicillin	0			0.5	23.9	69.7	5.8				
Enrofloxacin	1	85.5	12.4	1.1			1.1				
Gentamicin	NR							1.3	7.6	80.8	10.3
Penicillin	0		0.3	13.7	76.8	9.2					
Tetracycline	1				5.5	74.2	18.9	0.5			0.8
Trim-Sulph.[a]	6		57.1	30.5	6.6	2.1	1.6	0.5	1.6		

NR, not relevant as *Pasteurella* spp. have a low inherent susceptibility to aminoglycosides, as gentamicin.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim/sulphamethoxazole).

Beta-haemolytic streptococci

Isolates of beta-haemolytic streptococci are from clinical submissions of samples from various anatomical sites, but mainly from wounds or skin lesions, urine and the external ear canal (79%) in cats. The same cut-offs as for *Streptococcus equi* subsp. *zooepidemicus* have been applied for the tested beta-haemolytic streptococci isolates.

Resistance data for beta-haemolytic streptococci isolated from cats were included also in Swedres-Svarm 2011 (n=184) and in 2022 (n=128). As then, all the tested isolates were susceptible to penicillin (Table 4.38). Any reduced susceptibility to penicillin in beta-haemolytic streptococci should be controlled, i.e. if tested on pure culture and ensuring that organism identification and antimicrobial susceptibility test are accurate and reproducible.

Beta-haemolytic streptococci have a low inherent susceptibility to fluoroquinolones (as enrofloxacin), aminoglycosides (as gentamicin) and tetracyclines.

Table 4.38. Distribution of MICs and resistance (%) in beta-haemolytic streptococci isolated from cats, 2023. Clinical isolates from various locations.

Antibiotic	Resistance (%) 2023 n=96	Distribution (%) of MICs (mg/L)												
		≤0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	>64
Cephalotin	0						100							
Clindamycin	5					94.8			5.2					
Enrofloxacin	NR				8.3	64.6	25.0	2.1						
Erythromycin	7					92.7	1.0		6.3					
Gentamicin	NR						1.0	7.3	68.8	22.9				
Nitrofurantoin	0										100			
Penicillin	0	100												
Tetracycline	NR				9.4	1.0	5.2	32.3	26.0	26.0				
Trim-Sulph.[a]	0				100									

NR, not relevant as the inherent susceptibility is above concentrations that can be obtained during therapy.
[a]Concentration of trimethoprim given, tested in concentration ratio 1/20 (trimethoprim-sulphamethoxazole).

Indicator bacteria from animals

In programmes monitoring antibiotic resistance in the veterinary field, *Escherichia coli*, *Enterococcus faecalis* and *Enterococcus faecium* from the enteric flora of healthy animals, or bacteria contaminating food, serve as indicators of the presence of acquired resistance. The level of resistance in these so-called indicator bacteria reflects the magnitude of the selective pressure from antibiotic use in an animal population. Moreover, although these bacteria are unlikely to cause disease, they can be reservoirs for resistance genes that may spread to bacteria pathogenic to animals or humans. Resistance in indicator bacteria contaminating meat indicates the potential exposure of humans through the food chain.

During 2023, indicator *E. coli* from fattening pigs as well as from samples of pig and bovine meat were studied.

Samples from fattening pigs were collected at slaughter under the supervision of the National Food Agency (SLV) at six abattoirs that together processed more than 85% of the total number of pigs slaughtered in Sweden during 2023. The number of samples from each abattoir was roughly proportional to the annual slaughter volume of the abattoir and the sampling was distributed over the year. Each sample was randomly selected but represented a unique herd per day. Samples were sent to SVA for culture the same day or the next day after collecting and in the meantime kept refrigerated.

Samples of meat originating from outside EU were collected at border control posts under the supervision of the National Food Agency (SLV). All approved border control posts were engaged in the sampling, and at each post the first eligible meat sample of each meat category was sampled. After that, a number of consignments (based on the number of consignments the previous years) in the spring and autumn respectively were randomly selected for sampling. The exact meat lots to be sampled were randomly selected by the sampling personnel at the border control posts. Samples were sent to SVA for culture the same day or the next day after collecting and were in the meantime kept refrigerated.

All samples analysed for indicator *E. coli* were also screened for *E. coli* resistant to ESCs by selective culture on media supplemented with cefotaxime. For details on methodology see Material and methods, resistance in bacteria from animals.

Escherichia coli

Pigs

Escherichia coli was isolated from 174 (99%) of 176 cultured caecal samples from pigs. The majority of the isolates (73%) was susceptible to all antibiotics tested (Table 4.39). Resistance to ampicillin (18%), sulphonamides (17%), trimethoprim (16%) and tetracycline (12%) were the most common traits (Table 4.39 and 4.40). Twenty-four isolates (14%) were multiresistant, i.e. resistant to three or more antibiotics (Table 4.39 and Figure 4.13). All of these had resistance to sulphonamides and trimethoprim in their phenotype, and all but one had resistance to ampicillin. From an international perspective, levels of resistance in *E. coli* from pigs are low in Sweden. The proportion of isolates susceptible to all antibiotics tested has

been relatively stable in recent years (68% in 2015, 71% in 2017, 71% in 2019, 64% in 2021, and 73% in 2023). However, for some substances the situation has become less favourable (Figure 4.14). More specifically, the occurrence of resistance to ampicillin, sulphonamides, and trimethoprim in *E. coli* from pigs has increased considerably since 2008, and the occurrence of resistance to tetracycline has increased since 2017. Regarding substances in category B ("Restrict") of the AMEG classification (EMA, 2019a), resistance to polymyxins (colistin) has been tested for since 2011 but never detected, and resistance to quinolones and third generation cephalosporins (ceftiofur 2000-2005, cefotaxime 2005-2012, and cefotaxime and ceftazidime 2013 onwards) has remained stable at low rates (Figure 4.14). In 2023, none of the isolates were resistant to cefotaxime or ceftazidime.

However, using the more sensitive selective culture method, ESC resistant *E. coli* were isolated from 10 (3%) of 302 samples. In three of these isolates (1%), transferable genes for resistance to ESC were found. Two isolates had the $bla_{\text{CTX-M-15}}$ gene and one the $bla_{\text{DHA-1}}$ gene. The remaining seven isolates had an AmpC phenotype and genome sequencing of these isolates revealed mutations causing hyper-production of AmpC beta-lactamases, i.e. a shift from C to T at position 42. For more details and comments on occurrence of resistance to ESC, see section Antibiotic resistance in animals, Notifiable disease.

Meat

Escherichia coli was isolated from 5 of 9 samples of bovine meat and from 1 of 3 samples of pig meat sampled at border control posts. The isolates were from 3 of 3 sampled consignments of bovine meat and from the only sampled consignment of pig meat. All 5 isolates from bovine meat were susceptible to all antibiotics tested. The isolate from pig meat was resistant to chloramphenicol and tetracycline.

This was the second time that occurrence of resistance among indicator *E. coli* from meat sampled at border control posts was assessed in Svarm. Although little resistance has been detected thus far, the fact that only a small number of *E. coli* were isolated each year makes it difficult to draw conclusions from these results. None of the isolates were resistant to cefotaxime or ceftazidime. Likewise, no ESC resistant *E. coli* were isolated from the investigated samples when using selective culture. For more details and comments on occurrence of resistance to ESC, see section Antibiotic resistance in animals, Notifiable disease.

Figure 4.13. Proportion (%) of indicator *Escherichia coli* from broilers, turkeys, laying hens, pigs and cattle under one year of age with resistance to none, one-two, or three or more tested substances.

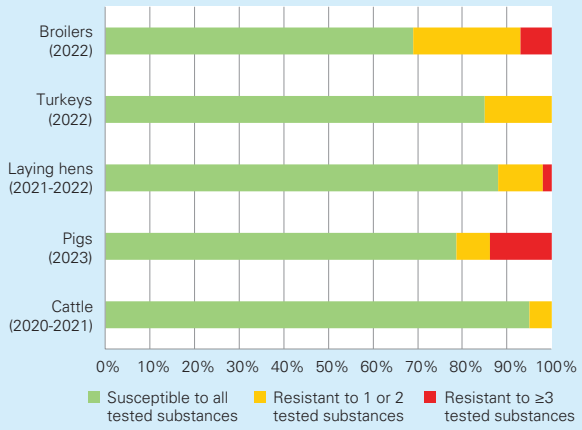
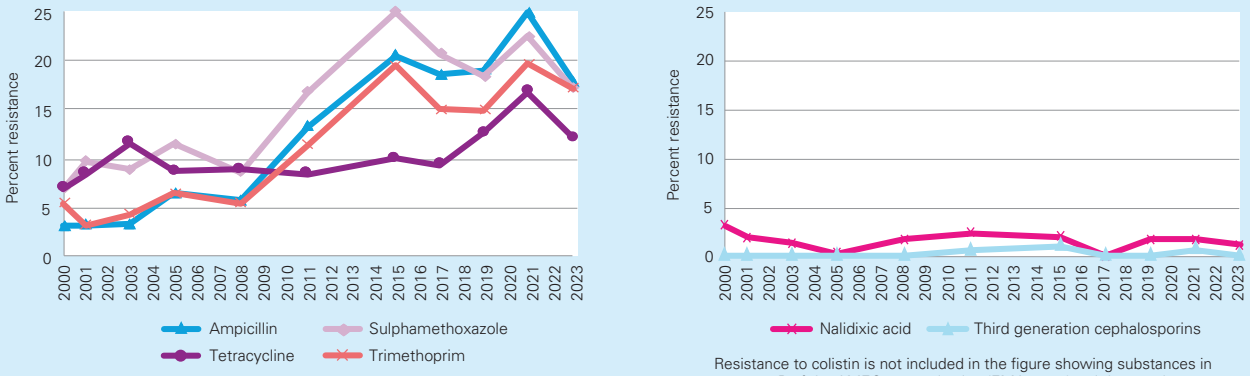


Figure 4.14. Resistance (%) in *Escherichia coli* from fattening pigs 2000-2023. The number of isolates each year varies (n=140-390, 2023 n=174).



Resistance to colistin is not included in the figure showing substances in category B of the AMEG categorisation (EMA, 2019) as it has not been detected during the years it has been investigated (2011-2023).

Table 4.39. Resistance (%) and multiresistance (%) in indicator *Escherichia coli* from fattening pigs, 2023. Most recent data on indicator *E. coli* from other sample categories are given for comparison.

Antibiotic	ECOFF (mg/L)	Resistance (%)							
		Broilers	Cattle[b]	Laying hens	Pigs	Sheep	Turkeys	Dogs	Horses
		2022 n=179	2020-21 n=101	2021-22 n=110	2023 n=174	2006-09 n=115	2022 n=34	2012 n=74	2010-11 n=274
Amikacin	>8	0	0	0	0	-	0	-	-
Ampicillin	>8	19	2	3	18	2	0	9	2
Azithromycin	>16	0	0	0	<1	-	0	-	-
Cefotaxime	>0.25	0	0	0	0	0	0	1	0
Ceftazidime	>1	0	0	0	0	-	0	-	-
Chloramphenicol	>16	0	0	1	3	0	0	0	<1
Ciprofloxacin	>0.06	5	0	2	2	<1	3	3	<1
Colistin	>2	0	0	0	0	-	0	0	<1
Gentamicin	>2	0	0	0	0	3	0	0	<1
Meropenem	>0.12	0	0	0	0	-	0	-	-
Nalidixic acid	>8	5	0	2	1	0	3	0	<1
Sulphamethoxazole	>64	11	2	3	17	7	9	4	15
Tetracycline	>8	7	2	5	12	<1	12	8	2
Tigecycline	>0.5	0	0	0	0	-	0	-	-
Trimethoprim	>2	9	2	4	17	2	0	1	16
Resistance (%) to 0->3 antibiotics[a]									
Susceptible to all above		69	95	88	73	89	85	84	83
Resistant to 1		23	4	8	7	8	6	8	2
Resistant to 2		1	2	2	6	3	9	7	12
Resistant to 3		4		2	6	<1			2
Resistant to >3		3			7			<1	1

[a]Ciprofloxacin and nalidixic acid as well as cefotaxime and ceftazidime were considered as one antibiotic class. [b]Cattle older than 6 months.

Table 4.40. Distribution of MICs and resistance (%) in *Escherichia coli* from intestinal content from fattening pigs (n=174), 2023.

Antibiotic	Resistance %	Distribution (%) of MICs (mg/L)																
		≤0.016	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	>512
Amikacin	0									98.3	1.7							
Ampicillin	18							1.1	35.1	42.0	4.0			17.8				
Azithromycin	<1								10.9	56.9	31.0	0.6	0.6					
Cefotaxime	0					100												
Ceftazidime	0					92.5	7.5											
Chloramphenicol	3										96.0	0.6	1.1	1.7	0.6			
Ciprofloxacin	2	96.0	2.3		1.1	0.6												
Colistin	0							100										
Gentamicin	0						78.7	19.0	2.3									
Meropenem	0		98.9	1.1														
Nalidixic acid	1									97.7	1.1				1.1			
Sulphamethoxazole	17										60.9	20.7	1.1					17.2
Tetracycline	12								87.9				0.6	11.5				
Tigecycline	0					96.6	3.4											
Trimethoprim	17					52.9	25.9	4.0					17.2					

Comparative analysis

Comparison of antibiotic sales in human and veterinary medicine

Data included and calculations

The numbers on the total amount of antibiotics consumed for systemic use to humans (ATC group J01 excluding methenamine, and A07AA oral glycopeptides; sales to hospitals and on prescriptions to individuals; ATC/DDD index version 2022) were retrieved as defined daily doses and calculated to kg active substance.

Figures on sales of antibiotics for use in animals (QJ01 and QA07AA) are those presented in Sales of antibiotics for animals except products for intramammary and intrauterine use (QG01 and QJ51). Sales for aquaculture were not included, nor were sales of drugs authorised for human use but sold for use in animals.

To estimate the biomass of the human population, data on population numbers by age were multiplied with the corresponding average body weights from studies made by Statistics Sweden in 2016. For animal body mass, the data on population correction unit for 2022 was used as a proxy for 2023 (EMA, 2022). This unit roughly corresponds to the total biomass of major animal populations, excluding dogs and cats.

Comparison of sales

A total of 64.4 and 8.9 tonnes of antibiotics were consumed in human and veterinary medicine, respectively, in 2023 from the included ATC classes. Beta-lactam antibiotics remain the most commonly prescribed antibiotics in both human and veterinary medicine and represent the largest volumes consumed, measured in kilograms. Other antibiotic products were consumed in smaller quantities than beta-lactams but considering their chemical and pharmacological properties, they could have a greater impact on the environment and the emergence of antibiotic resistance. The largest difference is noted for fluoroquinolones, where sales for humans are more than 150 times higher than for animals and constitute 4% of total sales for humans included in this analysis. For animals, fluoroquinolones sales constitute 0.2% of the total sales.

In total, 91.2 and 11.6 mg active antibiotic substance per kg estimated biomass were sold in 2023 in human and veterinary medicine, respectively. Total sales data do not take the heterogeneity of likelihood of exposure within the population into account. This is especially true for data on sales for use in animals, as certain substances may only or mainly be sold for use in one particular animal species. Consequently, the selective pressure in a particular subset of the population (i.e. a particular animal species) could be far larger than in the total population. Both in tonnes active substance and in mg per kg estimated biomass, antibiotic sales are higher for humans than for animals in Sweden.

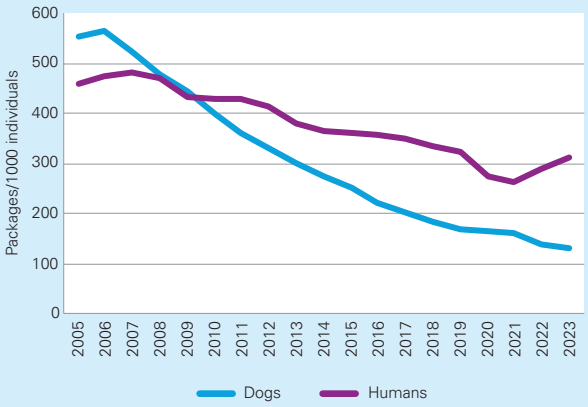
Comparison of outpatient sales for humans and dogs

One of the indicators of community consumption (outpatient consumption) used by ESAC-Net (Network for European surveillance of antimicrobial consumption in human medicine) is number of packages per 1000 inhabitants. This unit is regarded as a proxy for the number of treatments, although more than one package is sometimes used for one course.

To compare the consumption for humans and dogs, the number of packages of antibiotics dispensed for oral use in humans and dogs from 2005-2023 per 1000 individuals was used. Products with ATC-codes (Q)A07AA and (Q)J01, excluding methenamine, were included in the comparison. In both humans and dogs, the outpatient sales of oral antibiotics were highest in the first few years of the study period. From 2005 to 2023, sales decreased by 32% for humans and 76% for dogs.

Several factors may have triggered a change in behavior of canine practitioners in the 2000s, including the emergence of methicillin resistant staphylococci in dogs in 2006 and the availability of statistics on antibiotic prescriptions per animal species from 2005. For example, the insight that at the time, outpatient sales of antibiotics were higher for dogs than for humans clearly indicated room for improvement. This in turn generated a 'need to know more' among prescribers and national experts were able to allocate resources to support the process (Svarm 2008, Highlight: Decreased sales of antimicrobials for dogs). When it is appropriate to prescribe outpatient antibiotics rather than administrate them in inpatient care is likely to differ for humans and dogs, which should be considered when interpreting the larger sales decrease for dogs compared to humans.

Figure 5.1. Sales of outpatient antibiotics per 1000 individuals ((Q)A07AA and (Q)J01, oral formulations) to humans and dogs.



Comparison of antibiotic resistance in human and veterinary medicine

ESBL-producing Enterobacterales

Enterobacterales with $ESBL_A$ or $ESBL_M$, and their corresponding genes, can transfer between animals and humans (EFSA, 2011, de Been, 2014). The main route would be via food, but the possibility for direct transfer when handling animals should be kept in mind.

The available data show that ESBL-producing bacteria are generally rare in animals and food in Sweden. Previously, the occurrence in intestinal samples from broilers was high but it has decreased considerably in recent years. Moreover, previous investigations when the occurrence was higher has shown that $ESBL_{A-}$ or $ESBL_M$-producing *E. coli* constitute a small part of all the *E. coli* in the intestinal flora in a majority of the broiler samples. Finally, it has previously been shown that most isolates from humans in Sweden are not of the same types of $ESBL_A$ or $ESBL_M$ as in broilers. Hence, nothing indicates a need to revise the conclusion that food on the Swedish market is a limited source for ESBLs for humans (Börjesson et al., 2016). Nevertheless, continued vigilance against development of reservoirs of ESBL-producing Enterobacterales in animals is warranted.

MRSA

Zoonotic transmission of MRSA occurs by direct or indirect contacts. MRSA is reported globally in farm animals, companion animals, horses and wildlife. However, MRSA is still rare among animals in Sweden and the situation among humans is also favourable.

Livestock-associated MRSA

In the last decade, the zoonotic aspects on MRSA in farm animals has widened in many countries, largely due to spread of livestock-associated MRSA, and primarily clonal complex (CC) 398. This mainly concerns pigs but veal calves, broilers and dairy cows are also affected.

Based on our passive surveillance of MRSA in livestock, with occasional findings in samples from cow, pig, goat and sheep, the situation is considered favourable in Sweden. However, MRSA CC398 occurs among horses and *spa*-type t011 (n=9) were detected in 2023. We also found t011 for the first time in two dogs and one cat. All twelve isolates were PVL negative.

MRSA CC398 acquired in Sweden is uncommon in humans. Among all MRSA cases with available typing results in 2023, there were fifteen cases with *spa*-types t034 (n=10), t011 (n=3), t2383 (n=1) and t1973 (n=1). Nine of the isolates were PVL-negative while no information on PVL status was available for the remaining six isolates. The possibility of animal contacts as a source is often not pursued, consequently epidemiological information regarding this is scarce. Nevertheless, the low number of MRSA CC398 in humans in Sweden may indicate that MRSA is not widespread among animals in Sweden, as a high occurrence would lead to transmission to humans in contact with animals.

MRSA with *mecC*

Isolates of MRSA with *mecC* were first reported internationally from dairy cows and humans in 2011 (García-Álvarez et al., 2011, Shore et al., 2011, Ito et al., 2012). Throughout the years, MRSA with *mecC* have been isolated from several animal species (cat, cow, dog, hedgehog, goat, pig and sheep). The total number of cases are low even if there are a number of isolates from hedgehogs in research projects and from goats in an outbreak at a zoo.

In humans, cases of MRSA acquired in Sweden with *mecC* are also uncommon. In 2023, there were six reported cases with *spa*-types t843 (n=3), t373 (n=1), t9111 (n=1) and t1535 (n=1). The epidemiological information concerning possible animal contacts is scarce but some of the *spa*-types in cases from humans have also been found in cases from animals. However, even if there would be zoonotic transfer, it is not currently considered a public health problem, as the number of cases of MRSA with *mecC* in humans in Sweden is low.

MRSA-types typically associated with humans

MRSA isolated from dogs and cats often belong to *spa*-types seen in MRSA from humans. This supports the view that humans often are the source of MRSA in companion animals (EFSA 2009, CVMP, 2009). Spread can subsequently occur from animals to humans. However, the impact of companion animals as vectors for spread between humans is not known.

Conclusions

The MRSA situation in Sweden is still favourable both in humans and in animals. If this situation is preserved in animals, a reservoir of MRSA in animals with risk of spread to humans can be prevented. Biosecurity, with caution in trade of live animals and measures to prevent introduction by indirect routes, is important for preventing introduction and spread of MRSA in animal populations. Furthermore, antibiotic stewardship and infection prevention and control measures are important to prevent health care related spread between people, between animals or between people and animals.

For more information on MRSA in Sweden, see Antibiotic resistance in humans and Antibiotic resistance in animals.

MRSP

Staphylococcus pseudintermedius may act as an opportunistic pathogen in humans and there are several reports in the literature of infections in humans with a varying degree of severity. However, MRSP is not generally considered to be a zoonotic pathogen.

VRE

Using selective media, VRE have historically been isolated from a large proportion of broilers in Sweden. This occurrence has however decreased considerably. The occurrence in humans varies between years, mainly due to nosocomial outbreaks of causing high occurrence in some years. However, based on genotypical investigations of isolates, there are no indications that the presence of VRE in broilers in Sweden has affected the situation in Swedish health care.

Salmonella

Occurrence of *Salmonella* among farm animals, as well as among other animals, is low in Sweden and few incidents involve multiresistant strains. In 2023, the majority of the isolates (97 of 107; 90%) were susceptible to all antibiotics tested. Resistance to fluoroquinolones (e.g. ciprofloxacin) is rare and in 2019, a strain with ESBL was detected for the first time, in an environmental sample from a farm. Thus, the overall situation in the veterinary sector is favourable, largely due to the strategies in the Swedish salmonella control programme initiated in the 1950s.

More than half, 53%, of the notifiable cases of *Salmonella enterica* originate abroad and 45% are reported as domestic cases. The origin of the isolates used in generating AST results from Svebar are not known. Considering the low occurrence of *Salmonella* in food-producing animals in Sweden, the majority of food-related infections presumably have a foreign source. The high occurrence of resistance to fluoroquinolones in isolates from humans (24%) in comparison to the very rare occurrence of such resistance in isolates from Swedish food-producing animals also suggests that most of these isolates from human infections do not have a domestic origin.

Campylobacter

Resistance to fluoroquinolones, tetracycline and erythromycin among faecal isolates of *Campylobacter jejuni* from humans was 56%, 26% and 1.9% respectively. From animals, 176 isolates of *C. coli* from healthy pigs were tested. The resistance found was against fluoroquinolones (34%) and one isolate was resistant to erythromycin. In *Campylobacter* spp. isolated directly from animals, erythromycin resistance has only been found once before, in *C. coli* from a pig 2017. As in 2017, whole genome sequencing of this macrolide resistant isolate was performed, and no transferable macrolide resistance genes were found.

Resistance to erythromycin, the drug of choice for treatment of human campylobacteriosis, is rare among isolates from humans as well as animals in Sweden. In animals, it has only been found in two isolates from Swedish broiler meat (Svarm 2013) and in one isolate from a pig in 2017.

Clinical resistance in *Escherichia coli* from humans and animals

Comparison of resistance in bacteria from humans and different animal categories may indicate the magnitude of possible transfer of resistance between sectors and give insight into the drivers for resistance in the specific populations. However, in Swedres-Svarm, direct comparison of resistance is hampered because different interpretative criteria are used for bacteria from humans and animals. Data for bacteria from humans are interpreted with clinical breakpoints and presented as the proportion of isolates with clinical resistance. In contrast, data for bacteria from animals are mainly interpreted with epidemiological cut-off values (ECOFF) and presented as the proportion of isolates of non-wild type. For further information on interpretive criteria, see sections Guidance for readers and Materials and methods.

For the purpose of the comparison in this section, some data sets for *E. coli* from animals presented in Swedres-Svarm have been interpretated using clinical breakpoints for humans (Table 5.1).

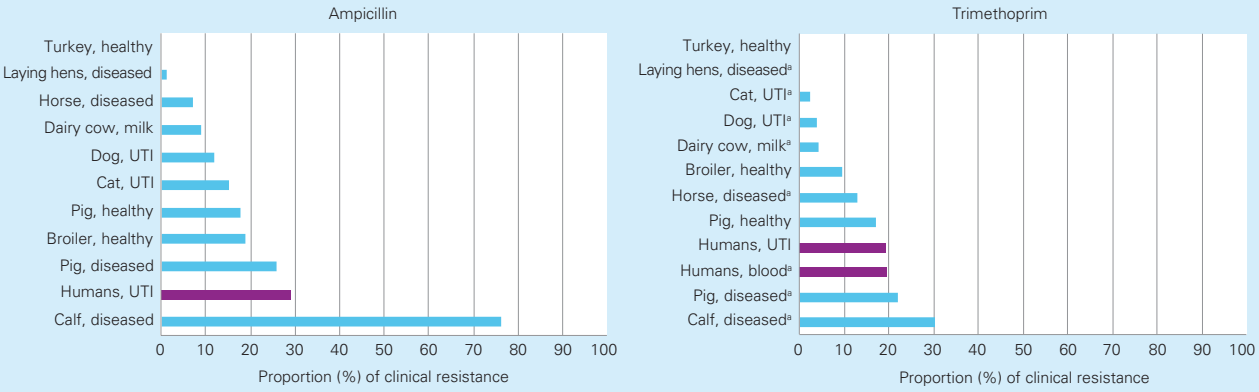
Resistance was generally more common in *E. coli* from humans than in isolates from animals (Table 5.1). Notably, clinical resistance to fluoroquinolones or 3rd generation cephalosporins was considerably more common in *E. coli* from humans than in isolates from animals with the highest occurrence in blood stream isolates from humans (Table 5.1). This is in line with the very low use of these antibiotic classes in animals (see Sales of antibiotics for animals). However, although few isolates of *E. coli* from animals show clinical resistance to fluoroquinolones, reduced susceptibility (i.e. non wild-type) is more common in some categories of diseased and healthy animals (see Antibiotic resistance in animals in this and previous reports). Possibly, the selection pressure from use of fluoroquinolones in animal populations is not sufficient to select for further mutations to clinical resistance in isolates with reduced susceptibility.

For the antibiotics commonly used in both animals and humans, e.g. ampicillin and trimethoprim, resistance is more frequent. In particular, the occurrence of resistance is high among clinical isolates from calves, pigs and humans (Table 5.1, Figure 5.2). When comparing resistance to trimethoprim, it should be considered that for some categories (i.e. clinical isolates from animals and blood isolates from humans), trimethoprim-sulphamethoxazole was tested. This could possibly result in a lower occurrence of resistance than if susceptibility to only trimethoprim had been tested. The comparatively high level of trimethoprim resistance in *E. coli* from the genital tract of mares most likely reflects the relatively common use of trimethoprim-sulphamethoxazole combinations in horses.

Occurrence of resistance to ampicillin or trimethoprim could also be due to co-selection by use of other antibiotics or to other factors selecting for resistance. For example, although exact data are missing, use of ampicillin or amoxicillin in cattle is believed to be low in Sweden. Nevertheless, resistance to ampicillin is common in both isolates from diseased calves and dairy cows. However, it is well known that multiresistant *E. coli* is common in pre-weaned dairy calves but that resistant strains are cleared as calves mature.

Moreover, the high occurrence of resistance to ampicillin or trimethoprim may be influenced in somce categories by a possible sampling bias, where animals are sampled due to therapeutic failures, inferring a selection of problematic cases.

Figure 5.2. A and B. Proportion of resistance (%) to ampicillin and trimethoprim in *Escherichia coli* from humans and animals interpreted with clinical breakpoints. For details see Table 5.1.



[a]Trimethoprim-sulphamethoxazole tested, BP >4 mg/L, NordicAST v. 13.0.

Table 5.1. Resistance (%) in *Escherichia coli* from various sample types from humans and different animal categories interpreted with clinical breakpoints (in brackets, mg/L) according to NordicAST v. 13.0 if not indicated by footnotes that other interpretive criteria were used.

Category	Sample type	Year	Number of isolates	Amp (>8)	Cip (>0.5)	Ctx (>2)	Gen (>2)	Mer (>8)	Nit (>64)	Tmp (>4)
Cat (UTI)	Urinary	2023	492	15.2	1.2[a]	0.2	0.6	0	0	2.4[b]
Dog (UTI)	Urinary	2023	902	11.8	0.6[a]	0.7	1.0	0	0	3.9[b]
Horse (e.g., endometritis)	Genital tract	2023	255	7.1	0[a]	0	1.2	0		13.0[b]
Calf (enteritis)	Faeces/Post-mortem	2021-22	46	76.1	0[a]	0	0	0		30.4[b]
Dairy cow (mastitis)	Milk	2023	44	9.1	0[a]	0	0	0		4.5[b]
Laying hens	Post-mortem	2022-23	86	1.2	0[a]	0	2.3	0		0[b]
Pig (enteritis)	Faeces/Post-mortem	2023	50	26.0	0[a]	0	0	0		22.0[b]
Broiler (healthy)	Intestinal content	2022	179	19.0	0	0	0	0		9.5
Cattle under 1 year (healthy)	Intestinal content	2020-21	56	1.7	0	0	0	0		1.8
Laying hens (healthy)	Intestinal content	2022-23	86	1.2	0	0	2.3	0		0
Pig (healthy)	Intestinal content	2023	174	17.8	0	0	0	0		17.2
Turkey (healthy)	Intestinal content	2022	34	0	0	0	0	0		0
Humans (UTI)	Urinary	2023	227 259	28.9	11.2	4.5[c]			1.2	19.3
Humans (bloodstream infections)	Blood	2023	10 730		14.7	7.6	6.4	0		19.7[b]

[a]Enrofloxacin tested, BP >1mg/L; [b]Trimethoprim-sulphamethoxazole tested, BP >4 mg/L, NordicAST v. 13.0; [c]Data from only five laboratories.

Background data, material, methods and references

Demographics and denominator data

Humans

Table 6.1. Denominator data (population in Sweden per region and age group) for calculation of antibiotic sales in humans, 2023. Data from the eHealth Agency.

	<1 years	1-4 years	5-19 years	20-44 years	45-64 years	65-84 years	≥85 years	All age groups	0-6 years
Blekinge	1 401	6 383	27 508	44 924	39 833	33 329	5 362	158 740	11 217
Dalarna	2 601	12 191	49 560	79 918	70 654	64 146	9 240	288 310	21 456
Gotland	471	2 230	9 813	16 680	15 588	14 347	2 044	61 173	3 999
Gävleborg	2 483	11 938	48 863	80 630	72 424	62 195	8 801	287 334	20 702
Halland	3 381	15 500	63 141	98 136	85 813	66 642	10 192	342 805	27 201
Jämtland	1 343	5 743	22 517	38 505	32 561	27 552	3 833	132 054	10 087
Härjedalen	1 168	5 638	22 850	38 841	32 455	27 840	3 878	132 670	9 841
Jönköping	3 750	17 309	67 811	113 534	88 645	67 299	10 765	369 113	30 022
Kalmar	2 196	10 359	41 561	68 453	61 440	55 250	8 452	247 711	18 006
Kronoberg	2 072	9 575	37 246	63 401	48 122	37 683	6 236	204 335	16 664
Norrbotten	2 125	9 826	39 334	73 370	62 483	54 119	7 920	249 177	17 083
Skåne	14 488	65 239	254 805	458 293	342 083	243 272	36 144	1 414 324	113 905
Stockholm	26 271	113 819	437 807	858 081	603 987	351 992	48 070	2 440 027	198 549
Sörmland	2 921	13 539	55 871	86 335	74 400	60 910	8 590	302 566	24 113
Uppsala	4 003	18 017	70 906	141 241	91 302	66 148	9 065	400 682	31 573
Värmland	2 549	11 503	46 996	82 086	70 923	60 285	9 634	283 976	20 450
Västerbotten	2 638	11 965	46 449	91 697	63 838	52 263	7 445	276 295	20 910
Västernorrland	2 054	9 983	41 611	67 310	61 730	52 966	7 611	243 265	17 368
Västmanland	2 868	12 612	49 891	85 194	68 737	53 311	8 100	280 713	22 232
Västra Götaland	18 156	79 318	306 320	579 290	425 855	304 446	45 271	1 758 656	138 495
Örebro	3 019	13 620	54 220	96 144	73 608	59 016	8 145	307 772	23 713
Östergötland	4 571	20 617	83 010	151 750	113 251	85 662	13 051	471 912	36 122
Sweden	**105 186**	**471 181**	**1 855 573**	**3 375 308**	**2 567 171**	**1 873 121**	**274 016**	**10 521 556**	**823 621**

Table 6.2. Denominator data (population in Sweden) for calculation of antibiotic sales in humans, 2000-2023. Data from the eHealth Agency.

Year	Population	Year	Population
2000	8 861 426	2012	9 482 855
2001	8 882 792	2013	9 555 893
2002	8 909 128	2014	9 644 864
2003	8 940 788	2015	9 747 355
2004	8 975 670	2016	9 851 017
2005	9 011 392	2017	9 995 153
2006	9 047 752	2018	10 120 242
2007	9 113 257	2019	10 230 185
2008	9 182 927	2020	10 327 589
2009	9 256 347	2021	10 379 295
2010	9 340 682	2022	10 452 326
2011	9 415 570	2023	10 521 556

Animals

Official statistics on agriculture in Sweden is provided by the Board of Agriculture. The Board of Agriculture maintains a statistical database accessible online (www.jordbruksverket.se). Annual figures on the number of animals are given in Table 6.3, on animals slaughtered in Table 6.4 and 6.5 and average herd size in Table 6.6. Readers are referred to the Board of Agriculture for further information.

In brief, the number of dairy cows and pigs has decreased notably over the last three decades but herd size has increased. During the same period, the number of beef cows has increased, as well as the number of chickens slaughtered.

Estimates of the number of dogs and cats are available from the Board of Agriculture for 2006 and 2012, and in a study by the company Novus in 2017. In 2012 the numbers of dogs and cats in Sweden were estimated to 784 000 and 1 159 000, respectively. The corresponding figures for 2017 were 881 000 and 1 443 000.

Table 6.3. Number of livestock and horses (in thousands) 1980-2023. From the statistical database of the Board of Agriculture.

Animal Species	1980	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Cattle												
Dairy cows	656	646	576	482	428	393	348	338	303	302	297	296
Beef cows	71	59	75	157	167	177	197	184	207	210	213	210
Other cattle >1 year	614	570	544	596	589	527	513	487	480	476	482	480
Calves <1 year	595	563	524	542	500	509	479	466	462	465	458	459
Total, cattle	1 935	1 837	1 718	1 777	1 684	1 605	1 537	1 475	1 453	1 453	1 449	1 444
Sheep												
Ewes and rams	161	173	162	195	198	222	273	289	263	272	264	264
Lambs	231	252	244	266	234	249	292	306	238	252	245	222
Total, sheep	392	425	406	462	432	471	565	595	501	523	510	486
Pigs												
Boars and sows	290	260	230	245	206	188	156	142	131	129	127	113
Fattening pigs >20 kg	1 254	1 127	1 025	1 300	1 146	1 085	937	830	869	845	895	852
Piglets <20kg	1 170	1 113	1 009	769	566	539	427	384	368	376	371	399
Total, pigs	2 714	2 500	2 264	2 313	1 918	1 811	1 520	1 356	1 368	1 351	1 393	1 304
Hens for egg production												
Laying hens	5 937	6 548	6 392	6 100	5 670	5 065	6 061	7 571	8 403	6 363	7 919	7 717
Chickens reared for laying	2 636	2 159	2 176	1 812	1 654	1 697	1 647	1 842	2 420	2 390	1 722	2 700
Total, hens for egg-production	8 573	8 708	8 568	7 912	7 324	6 762	7 707	9 413	10 823	8 753	9 641	10 417
Horses												
Total, horses						283[a]	363	356[b]				

[a]Data from 2004; [b]Data for 2016

Table 6.4. Number of animals slaughtered (in thousands) at slaughterhouses, 1980-2023. From the statistical database of the Board of Agriculture.

Animal Species	1980	1985	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Cattle												
Cattle > 1 year	574	584	523	502	490	433	425	406	420	400	401	410
Calves < 1 year	130	152	70	30	39	33	27	22	13	11	11	11
Total, cattle	704	736	593	532	529	466	453	428	434	412	412	421
Sheep	302	328	280	189	202	206	255	256	240	227	227	229
Pigs	4 153	4 283	3 653	3 743	3 251	3 160	2 936	2 560	2 623	2 651	2 672	2571
Broilers	40 466	36 410	38 577	61 313	68 617	73 458	78 507	95 974	110 335	115 629	112 852	109 380
Turkeys							495	475	521	528	533	526

Table 6.5. Quantity of livestock slaughtered (in 1000 tonnes) at slaughterhouses, 1995-2023. From the statistical database of the Board of Agriculture.

Animal Species	1995	2000	2005	2010	2015	2020	2021	2022	2023
Cattle	142	150	136	138	133	141	136	135	421
Cattle > 1 year	140	145	131	134	130	138	134	133	136
Calves < 1 year	3	4	5	4	4	2	2	2	2
Sheep	4	4	4	5	4	5	5	5	5
Pigs	309	277	275	264	233	247	253	254	243
Broilers	74	90	96	112	138	167	180	172	172
Turkeys				3	4	5	5	5	5

Table 6.6. Average number of animals per holding 1995-2023. From the statistical database of the Board of Agriculture.

Animal Species	1995	2000	2005	2010	2015	2020	2021	2022	2023
Cattle									
Dairy cows	27	34	46	62	82	98	102	106	110
Beef cows	9	12	14	16	18	21	21	22	21
Ewes and rams	20	25	29	32	32	33	32	32	32
Boars and sows	31	63	156	156	186	185	173	175	156
Fattening pigs	157	294	471	664	845	945	942	951	990

Materials and methods, sales of antibiotics

Legal framework and distribution of drugs

Marketing of drugs in Sweden is regulated by the Medicinal Products Act, which applies both to human and veterinary medicinal products. According to this Act, a medicinal product may not be sold until it has been granted marketing authorisation by the Medical Products Agency (MPA). In case there are no authorised medicinal products for a certain condition, the MPA can permit sales on special license for a pharmacy to sell a product that is otherwise not authorised in Sweden. There are several different license types based on whether it is for an individual, an animal or a whole clinic. The medical product can be prescribed and obtained from any pharmacy or ordered to clinics using requisitions.

Medicinal and veterinary medicinal products in which an antibiotic is the active substance are only dispensed through pharmacies, which are supplied by drug wholesalers or manufacturers. In outpatient care, antibiotic drugs (including veterinary medicinal premixes for production of mecicated feed) may only be sold on prescriptions, automated dose dispensing (individually packed doses of drugs often dispensed to the elderly) or requisitions. Prescribers (veterinarians or medical doctors) are not permitted to own a pharmacy or to otherwise sell medicinal products for profit. In hospital care, both for humans and animals, antibiotics are usually bought on requisition from pharmacies, although some regions manage drug supplies to human hospitals independently. Veterinarians may deliver products to the animal caretaker in relation to the examination of a case for self-cost (no profit) and such products are also bought on requisition.

All pharmacies in Sweden are required to provide statistics on sales of all products on a regular basis to the Swedish eHealth Agency (eHälsomyndigheten). This agency maintains a national database with sales statistics for all drugs and provides statistics to the competent national and regional authorities and, on a commercial basis, to others. These data are protected by the Public Access to Information and Secrecy Ordinance and publication of data needs to be carefully reviewed to avoid risk of disclosure of sensitive information. For this publication, measures for protection of information have been taken and for sales of antibiotics for humans, consent has been obtained from the legal entities concerned.

The ATC classification system and defined daily doses (DDD)

Since 1988, the Anatomical Therapeutic Chemical (ATC) and ATCvet classification systems recommended by the WHO are used in Sweden for national drug statistics. For drugs sold for use in humans, to facilitate drug utilisation studies from a medical point of view, the measure defined daily dose (DDD) is used as a unit of comparison in drug statistics. The DDD for a drug is established on the basis of the assumed average dose per day for the drug given to adults for its main indication. If possible, the DDD is given as the amount of active substance. The DDDs are usually equal for all dosage forms of a preparation. The statistical data systems of the Swedish eHealth Agency are upgraded annually according to the recommendations made by the WHO Collaborating Centre for Drug Statistics Methodology in Oslo, Norway. Sales figures are presented as number of DDDs per 1 000 inhabitants per day, which gives an estimate of the proportion of the population daily exposed to a particular drug. This number is a rough estimate and should be interpreted with caution.

All data on the number of DDDs in this report are displayed in the 2024 version of the ATC/DDD index, available at https://www.whocc.no/atc_ddd_index/.

Antibiotic sales in humans

Sales statistics on medications have been monitored and compiled since 1975, initially by the National Corporation of Swedish Pharmacies. The sales are registered as number of DDDs, cash value and number of packages. Outpatient care data include information on the sales of prescribed drugs from all Swedish pharmacies by the prescription survey, running since 1974. The statistical material was until 1995 based on samples of dispensed prescriptions. From 1996, all prescriptions dispensed by pharmacies are included. From 1999, individually packed doses of drugs dispensed e.g. to the elderly are also included in the survey. Recorded data are trade name, quantity, patient fee, total cost, sex and year of birth of the patient. Data can be expressed as DDD per 1 000 inhabitants per day or number of prescriptions per 1 000 inhabitants per year. Inpatient care data include drugs delivered by all hospital pharmacies to the hospital departments (see the section "Completeness of data" below). The sales are expressed as cash value, number of packages and number of defined daily doses.

Following the de-monopolisation of the pharmacy market in Sweden in July 2009, the responsibility for collection of drug statistics was transferred to the core infrastructure supplier for all pharmacies, Apotekens Service. In January 2014, the activities in the state-owned company Apotekens Service were transferred to the Swedish eHealth Agency. The Swedish eHealth Agency aims to contribute to improved health care, improved public health and better caring by pursuing development of a national e-health infrastructure. The agency is also responsible for Sweden's national drug statistics.

Completeness of data reported to the Swedish eHealth Agency

In Sweden, pharmacies are required by law to report sales statistics to the Swedish eHealth Agency. Concerns have been raised that after the re-regulation of the pharmacy market, the statistics on sales of medical products to hospitals in Sweden is less complete than before. After the re-regulation, regions can choose to manage drug supplies to hospitals independently. If so, the regions are not required to report data to the national database. However, to the best of our knowledge, all regions are currently reporting data to the Swedish eHealth Agency.

Data sources and inclusion criteria

Data on sales of antibiotics in outpatient and inpatient care as well as population data are obtained from the Swedish eHealth Agency. For the overall statistics, the data include all antibacterial products marketed in Sweden in the ATC class J01. The data on sales of antibiotics for humans include all sales, even if the antibacterial (J01) is prescribed by a veterinarian. Throughout this report, methenamine is excluded in all displays of J01 as a group. Measures used are defined daily dose per 1 000 inhabitants per day (DDD/1 000 inhabitants per day) and prescriptions per 1 000 inhabitants per year. Every purchase of a drug prescribed in outpatient care is also recorded in the Prescribed Drug Register, maintained by the Swedish National Board of Health and Welfare. This register provides the opportunity to link each prescription to an individual, which makes it possible to study the actual number of individuals or the fraction of the population treated with a specific drug. Thus, some of the data are presented as treated inhabitants per 1 000 total inhabitants per year. Data on the age-adjusted average body weight of the population in Sweden were obtained from Statistics Sweden, the agency responsible for official statistics in Sweden. Antibiotic sales to inpatient care are measured in DDD per 1 000 inhabitants per day. The number of DDDs is obtained from the Swedish eHealth Agency.

For antibiotics sold in Sweden on a special license, information regarding strength and package size may be incomplete, preventing proper DDD calculation. Therefore, when data is obtained from the Swedish eHealth Agency in DDD, these products sold on special license are not properly included and usage of certain antibiotics could be underestimated. For most antibiotic classes, this difference is negligible. However, for some antibiotic substances, such as several cephalosporins, this underestimation has a notable effect on data represented in DDD.

Trend analysis

In the report, some general regression models were executed in the section "Sales of antibiotics". Time was used as explanatory variable and the outcome was the sales of antibiotics, adjusted for population size in Sweden, data on population provided by the eHealth Agency. The analyses were executed on a basis of a negative binomial distribution.

The Swedish Prescribed Drug Register

Since July 2005 the National Board of Health and Welfare supplies an individual based register on all drugs prescribed and dispensed in outpatient care. The register includes information on the number of individuals treated with at least one course of antibiotics during a specific period of time, i.e. number of treated inhabitants per 1 000 total inhabitants per year (Inhabitants/1 000/year). It is also possible to follow the number of purchases per person.

Definitions of DDD 2023

Table 6.7. DDD for all antibiotic substances (J01) registered in Sweden in 2023.

	DDD (g)		DDD (g)
J01AA02- doxycycline	0.1	J01DI54- ceftolozane and enzyme inhibitor	3
J01AA04- lymecycline	0.6	J01EA01- trimethoprim	0.4
J01AA07- tetracycline	1	J01EC02- sulfadiazin	0.6
J01AA08- minocycline	0.2	J01EE01-sulfamethoxazole and trimethoprim	1.92
J01AA12- tigecycline	0.1	J01FA01- erythromycin	1
J01BA01- chloramphenicol	3	J01FA01- erythromycin erythylsuccinate tablets	2
J01CA01- ampicillin- parenteral	6	J01FA06- roxithromycin	0.3
J01CA01- ampicillin- oral	2	J01FA09- clarithromycin- oral	0.5
J01CA04- amoxicillin	1.5	J01FA10- azithromycin- parenteral	0.5
J01CA08- pivmecillinam	0.6	J01FA10- azithromycin- oral	0.3
J01CA12- piperacillin	14	J01FA15- telithromycin	0.8
J01CA17- temocillin	4	J01FF01- clindamycin- parenteral	1.8
J01CE01- benzylpenicillin	3.6	J01FF01- clindamycin- oral	1.2
J01CE02- phenoximethylpenicillin (penicillin V)	2	J01FG01- pristinamycin	2
J01CE08- benzathine benzylpenicillin	3.6	J01GB01- tobramycin- parenteral	0.24
J01CF01- dicloxacillin	2	J01GB01- tobramycin- oral inhalation solution	0.3
J01CF02- cloxacillin	2	J01GB01- tobramycin- oral inhalation powder	0.112
J01CF05- flucloxacillin	2	J01GB03- gentamicin	0.24
J01CR02- amoxicillin and enzyme inhibitor	1.5	J01GB06- amikacin	1
J01CR05- piperacillin and enzyme inhibitor	14	J01MA01- ofloxacin	0.4
J01DB01- cefalexin	2	J01MA02- ciprofloxacin- parenteral	0.8
J01DB04- cefazolin	3	J01MA02- ciprofloxacin- oral	1
J01DB05- cefadroxil	2	J01MA06- norfloxacin	0.8
J01DC01- cefoxitin	6	J01MA12- levofloxacin- oral/parenteral	0.5
J01DC02- cefuroxime- parenteral	3	J01MA12- levofloxacin- inhalation	0.24
J01DC02- cefuroxime- oral	0.5	J01MA14- moxifloxacin	0.4
J01DC04- cefaclor	1	J01XA01- vancomycin	2
J01DD01- cefotaxime	4	J01XA02- teicoplanin	0.4
J01DD02- ceftazidime	4	J01XA04- dalbavancin	1.5
J01DD04- ceftriaxone	2	J01XB01- colistin- parenteral	9 MU
J01DD08- cefixime	0.4	J01XB01- colistin- oral	3 MU
J01DD14- ceftibuten	0.4	J01XB02- polymyxin B	0.15
J01DD52- ceftazidime and enzyme inhibitor	6	J01XC01- fusidic acid	1.5
J01DE01- cefepime	4	J01XD01- metronidazole	1.5
J01DF01- aztreonam- parenteral	4	J01XE01- nitrofurantoin	0.2
J01DF01- aztreonam- inhalation	0.225	J01XX01- fosfomycin- parenteral	8
J01DH02- meropenem	3	J01XX01- fosfomycin- oral	3
J01DH03- ertapenem	1	J01XX04- spectinomycin	3
J01DH51- imipenem and enzyme inhibitor	2	J01XX05- methenamine- hippurate	2
J01DH52- meropenem and enzyme inhibitor	3	J01XX05- methenamine- mandelate	3
J01DH56- imipenem and enzyme inhibitor	2	J01XX08- linezolid	1.2
J01DI01- ceftobiprolmedocaril	1.5	J01XX09- daptomycin	0.28
J01DI02- ceftarolinfosamil	1.2	J01XX11- tedizolid	0.2
J01DI04- cefiderokol	6		

Sales of antibiotics for animals

Data sources, inclusion criteria and analysis

For the overall statistics, the data include all products with antibiotics as active substance marketed in Sweden and sold for use in terrestrial animals in the ATCvet classes QA07, QJ01, QG01A and QJ51. Products that are authorised in other countries and sold on special license are also included. Medicinal products authorised for human use but prescribed for use in animals are not included in the overall statistics.

Data are retrieved as number of packages sold per product-presentation. Calculation to kg active substance is done based on information on strength and package size obtained from the national product register of the MPA, or for products sold on special license from other sources, e.g. pharmacies.

Updates and uncertainties

Antibiotic products sold with special licence (products prescribed and sold on exemption from Swedish market authorisation) are included in the dataset. However, in 2011 it was noticed that the information on sales of products with special licence was less complete than in previous years. Figures for 2011 are therefore likely to be a slight underestimate. Between 2012 and 2014, efforts were made to obtain sales data for major products on license from pharmaceutical companies to adjust the data on pharmacy sales. The reporting system was adjusted, and it is assumed that from 2015 data from the eHealth Agency on sales of products with special licence is no less complete than for products with general marketing authorisation.

In 2021, the protocol for the European surveillance of veterinary antimicrobial consumption (ESVAC) was updated regarding conversion factors for certain benzylpenicillins (EMA, 2021). Consequently, data presented in Swedres-Svarm for procaine benzylpenicillin from 1980 and onwards were recalculated with the new conversion factor (0.57 compared to previously 0.6) and previously published data has been updated as from Svarm 2020.

Following a re-regulation of the Swedish pharmacy market in 2010, there were indications of a lack of completeness regarding data on pharmacy sales. This mainly affected injectable products sold in requisition. As from 2015, completeness seemed to be as high as before the re-regulation.

Investigations into indications of lack of completeness of data for 2022 revealed a significant lack of completeness for in particular 2020 and 2022. The causes for this latter lack of completeness were identified and data corrected, leading to historical updates in Swedres-Svarm 2022.

Materials and methods, resistance in bacteria from animals

Isolation and identification of bacteria

Antibiotic resistance as notifiable diseases

ESBL

$ESBL_{A,}$ $ESBL_{M}$ and $ESBL_{CARBA}$-producing *Escherichia coli* were isolated by culture on MacConkey agar (Oxoid) with cefotaxime (1 mg/L), CHROMID CARBA (CC) agar (bioMérieux) and CHROMID OXA 48 (CO) agar (bioMérieux), with prior enrichment in buffered peptone water (BPW).

Intestinal samples: Shortly, 1 g of intestinal content was diluted in 9 ml BPW and incubated at 37°C overnight. From the BPW solution 10 µl was spread each on a plate of MacConkey agar with cefotaxime (1 mg/L), CC agar and CO agar. The plates were incubated overnight at 44°C (MacConkey agar) or 35°C (CC, CO agar). From MacConkey agar with cefotaxime up to three lactose positive colonies with morphology typical for *E. coli* was sub-cultured on MacConkey agar with cefotaxime and then sub-cultured again on horse-blood agar (5% v/v), after which the isolate was tested for production of tryptophanase (indole). Only lactose and indole positive isolates with typical morphology were selected for susceptibility tests and further tested for ESBL production. Isolates suspected to be Enterobacterales species on CC agar and CO agar were sub-cultured on MacConkey agar and then sub-cultured again on horse blood agar. These isolates were species identified by MALDI-TOF MS and if positive for any Enterobacterales species the isolate would be further tested for ESBL production.

Meat samples: Briefly, 25 g of surface meat was homogenised in 225 ml BPW and incubated at 37°C overnight. From the BPW overnight culture 10 µl per agar plate was spread on MacConkey agar with cefotaxime (1 mg/L), CC agar and CO agar and incubated overnight at 44°C (MacConkey agar) or 35°C (CC, CO agar). From MacConkey agar with cefotaxime one lactose positive colony with morphology typical for *E. coli* was sub-cultured on MacConkey agar with cefotaxime and then sub-cultured again on horse-blood agar (5% v/v), after which the isolate was tested for production of tryptophanase (indole). Only lactose and indole positive isolates with typical morphology were selected for susceptibility tests and further tested for ESBL production. From MacConkey agar with cefotaxime up to three lactose positive colonies with morphology typical for *E. coli* was sub-cultured on MacConkey agar with cefotaxime and then sub-cultured again. *Escherichia coli* like colonies on CC agar and CO agar were sub-cultured on MacConkeyagar, and if they were lactose positive, they were sub-cultured on horse-blood agar. Lactose positive isolates were species identified by MALDI-TOF MS and if positive for any Enterobacterales species the isolate would be further tested for ESBL production.

Clinical isolates from cats, dogs, and horses were submitted to the Dept. of Animal Health and Antimicrobial Strategies, SVA as bacterial strains. Isolates were species identified by MALDI-TOF MS.

MRSA and MRSP

Isolates were species identified by MALDI-TOF MS and tested for presence of *mecA* and *mecC* with PCR (see below, Genotyping). Isolates were susceptibility tested using microdilution (see below, Susceptibility testing).

Zoonotic pathogens

Salmonella

Salmonella was isolated and identified at the Dept. of Microbiology, SVA or at regional laboratories in accordance with standard procedures. All samples within official control programmes are cultured according to the procedures detailed by the MSRV (ISO 6579-1:2017). Confirmatory identification and serotyping were performed according to the procedures of White-Kauffmann-Le Minor. For certain isolates, the serovar was verified by whole genome sequencing.

Campylobacter

Campylobacter coli from pigs were isolated and identified at the Dept. of Animal Health and Antimicrobial Strategies, SVA. Samples were cultured directly on modified Charcoal Cefoperazone Deoycholate agar (mCCDA) and Butzler selective agar according to Campylobacter EURL-protocol for isolation, identification, and storage of *Campylobacter jejuni* and *Campylobacter coli* for the EU monitoring of antimicrobial resistance. The plates were incubated at 41,5°C in microaerophilic environment for 48h. Identification was based on colony morphology and all isolates were species identified by MALDI-TOF MS. The isolates were stored in -70°C until tested. Selection of colonies was equally distributed between the selective agars.

Clinical isolates from animals

Clinical isolates were isolated and identified with accredited methodology following standard procedures at SVA.

Indicator bacteria

Escherichia coli

After the initial dilution in BPW and incubation (see screening for ESBL above), 10 µL was spread on MacConkey agar and incubated overnight at 44°C.

Up to three lactose positive colonies with morphology typical for *E. coli* was sub-cultured on horse-blood agar (5% v/v), after which the isolate was tested for production of tryptophanase (indole). Only lactose and indole positive isolates with typical morphology were selected for susceptibility tests.

Susceptibility testing

Microdilution

At SVA, fast growing aerobic bacteria, *Campylobacter* and bacteria from fish are tested for antibiotic susceptibility with accredited methodology using dilution methods in cation adjusted Mueller-Hinton broth (CAMHB) (Difco). Tests are performed following the standards for microdilution of the Clinical and Laboratory Standards Institute (CLSI, 2024). The microdilution panels used are produced by Thermo SCIENTIFIC Trek diagnostics systems (Sensititre) and for *Brachyspira* spp. the panels are produced at Section of Substrate, SVA (VetMIC) and Merlin, Bruker. Different panels are used depending on the bacterial species tested and the purpose of the investigation (monitoring or clinical diagnostics). Minimum inhibitory concentration (MIC) is recorded as the lowest concentration of an antibiotic that inhibits bacterial growth.

Some adaptations from the CLSI standard are employed. For *Pasteurella* spp. the tests are made by dilution in CAMHB supplemented with 5-10% horse serum followed by incubation in CO_2, 37°C for 16-18 hours. For testing of *A. pleuropneumoniae* dilution in HTM broth was used and with incubation in CO_2 at 37°C for 18-24 hours. *Streptococcus* spp. were tested using CAMHB supplemented with 5-10% horse serum followed by incubation at 35°C for 16-18 hours.

Susceptibility of *C. coli* was tested according to the CLSI standard M45 Ed3 for fastidious bacteria (CLSI, 2015).

Susceptibility of *Brachyspira hyodysenteriae* and *B. pilosicoli*, was tested by a broth dilution method described by Karlsson et al. (2003), in tissue culture trays with 48 wells per plate. The wells were filled with 0.5 ml of a suspension of bacteria ($1x10^6$-$5x10^6$ CFU/ml) in brain heart infusion broth (BHI) with 10% foetal calf serum and incubated in an anaerobic atmosphere at 37°C for four days on a shaker.

Bacteria from fish are tested for antibiotic susceptibility by broth microdilution adapted for aquatic bacteria according to CLSI (2020a).

Phenotypic confirmatory tests for production of extended spectrum beta-lactamases (ESBLs) in Enterobacterales were performed with and without clavulanic acid in Sensititre EUVSEC2 microdilution panels and interpreted according to EUCAST.

Genotyping

Suspected isolates of MRSA and MRSP were confirmed by detection of the *mecA* and *mecC* genes applying real-time PCR as described by Pichon et al. (2012). *Spa*-typing, a single locus sequence typing method using the polymorphic region X of the protein A gene, was performed on all index isolates confirmed as MRSA, either according to Harmsen et al. (2003) followed by *spa*-type determination using BioNumerics® (Applied Maths) or by the assembly of raw whole genome sequence data (see below) using the SKESA assembler (Souvurov et al., 2018) followed by *spa*-type determination using SeqSphere+ 10 software (Ridom GmbH, Germany). ST types were found in confirmed MRSP isolates using SeqSphere+ 10 software (Ridom GmbH, Germany) or given ST types by submitting data to Public databases for molecular typing and microbial genome diversity (www.pubmlst.org).

Isolates of Enterobacterales phenotypically confirmed as $ESBL_M$ were subjected to PCR detecting genes encoding $ESBL_M$ (Perez-Perez and Hanson, 2002) and $ESBL_A$ (Woodford et al., 2006; Fang et al., 2008). Isolates positive in PCR, phenotypically confirmed as $ESBL_A$ or suspected of being $ESBL_{CARBA}$ were subjected to genome sequence analysis.

DNA from confirmed ESBL-producing Enterobacterales, MRSA, and MRSP was extracted from overnight cultures on

horse-blood agar using EZ1 DNA tissue kit (Qiagen, Halden, Germany), according to the recommendations of the manufacturer. DNA was sent to Clinical Genomics Stockholm, Science for Life Laboratory (Solna, Sweden) for library preparation and paired-end sequencing using Illumina technologies. Reads were trimmed with Trimmomatic 39 (Bolger et al., 2014) and genome assembly was performed with SPAdes 3.14.0 (Prjibelski et al., 2020), followed by Pilon 1.23 (Walker et al., 2014) with default settings to correct assemblies. The specific ESBL-gene was determined using Resfinder 4.4.2 software (2023-11-27) with ResFinder 2.2.1 database (2023-10-27) (Bortolaia et al., 2020; Camacho et al., 2009).

Quality assurance system

Laboratories performing antibiotic susceptibility testing at SVA are accredited according to ISO/IEC 17025:2017 by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) to perform antibiotic susceptibility tests with microdilution methods. The Dept. of Microbiology is accredited for isolation and identification of animal pathogens and of *Salmonella* according to the same standard. The Dept. of Animal Health and Antimicrobial Strategies is accredited for isolation of *E. coli* in the monitoring program, both ESBL and indicator *E. coli*.

For susceptibility tests of zoonotic, pathogenic and indicator bacteria, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, *Staphylococcus aureus* CCUG 15915 (analogue to ATCC 29213), *Actinobacillus pleuropneumoniae* ATCC 27090, *Trueperella pyogenes* CCUG 13230, *Acinetobacter baumannii* 2012-70-100-69 - EURL 69 (used for control of higher concentrations of cephalosporins and carbapenems), *Aeromonas salmonicida* subsp. *salmonicida* CCUG 2116 (analogue to ATCC 14174), *Flavobacterium psycrophilum* CCUG 35200 (analogue to ATCC 49418), *Mycoplasma bovis* Donetta PG45^T ATCC 25523^T and *Campylobacter jejuni* CCUG 11284 (analogue to *Campylobacter jejuni* ATCC 33560) were included as quality controls. When testing animal pathogens relevant control strains were included and evaluated at least once weekly. For testing of *Brachyspira*, the *B. hyodysenteriae* type strain B78T ATCC 27164^T was used for quality control.

The Dept. of Animal Health and Antimicrobial Strategies participates once a year in two proficiency tests for antibiotic susceptibility testing, one for isolation and antibiotic susceptibility testing and one comparative test for antibiotic susceptibility testing. These are arranged by the European Union Reference Laboratory - Antimicrobial Resistance and as a national ring trial. We also participate in the DTU genomic proficiency test once a year. Likewise, the Dept. of Microbiology participates in proficiency tests concerning isolation and identification of *Salmonella* and general clinical veterinary bacteriology and susceptibility tests.

Data handling

Records such as source of cultured sample, identification results, antibiotic susceptibility etcetera were registered in a laboratory information management (LIM) system at SVA.

Cut-off values for resistance

For interpretation of MICs from susceptibility testing of zoonotic bacteria (*Salmonella* and *Campylobacter*) and indicator bacteria (*Escherichia coli* and enterococci) epidemiological cut-off values (ECOFFs) issued by EUCAST (www.eucast.org) or values suggested by the European Food Safety Authority are used. For some antibiotics, values based on MIC distributions obtained in Svarm are used.

ECOFFs are used when available also for clinical isolates from animals. When ECOFFs are not available, or the range of concentrations tested precludes use of a recommended value, values based on MIC distributions obtained in Svarm are used, but clinical breakpoints issued by CLSI (CLSI, 2024) or epidemiological cut-offs (ECVs) issued by CLSI (CLSI, 2020b) are also taken into consideration.

ECOFFs and ECVs classify isolates with acquired reduced susceptibility as non-wild type. In Svarm, non-wild type isolates are called resistant. This classification is relevant for monitoring purposes, but it should be understood that resistance defined in this manner not always implies clinical resistance.

Svarm 2000–2023

The number of isolates of different matrices reported in Svarm since 2000 is available as supplementary material on the SVA web page (www.sva.se/svarm).

Table 6.8. Cut-off values (mg/L) for resistance. Values in red are current EUCAST epidemiological cut-off values (ECOFFs), values in blue are CLSI ECVs, black underlined values deviate from ECOFFs and ECVs, and for values in black, ECOFFs or ECVs are not defined.

Antibiotic	*Aeromonas salmonicida*	*Actinobacillus pleuropneumoniae*	*Brachyspira hyodysenteriae*	*Campylobacter coli*	*Escherichia coli* (indicator)	*Escherichia coli* (pathogen)	*Flavobacterium columnare*	*Flavobacterium psychrophilum*	*Klebsiella pneumoniae*	*Mannheimia haemolytica*	*Pasteurella multocida*	*Pseudomonas aeruginosa*	*Salmonella enterica*	*Staphylococcus pseudintermedius*	*S. felis, S. schleiferi*	*Staphylococcus aureus*	*Streptococcus suis*	*Streptococcus zooepidemicus*
Amikacin					>8								>4					
Ampicillin		>0.5			>8	>8					>0.5		>4					
Azithromycin					>16								>16					
Cefalexin						>32												
Cefepime					>0.12													
Cefotaxime					>0.25	>0.25			>0.25				>0.5					
Cefoxitin																>4		
Ceftazidime					>1								>2					
Ceftiofur											0.12							
Cephalothin														>1	>1	>1		>2
Chloramphenicol				>16	>16								>16			>16		
Ciprofloxacin				>0.5	>0.06								>0.12			>2		
Clindamycin														>0.5	>0.5	>0.5[c]	>0.5	>0.5
Colistin					>2	>2			>2			>4						
Doxycycline		>2	>0.5															
Enrofloxacin		>0.12			>0.12	>0.12			>0.12	>0.12	>0.06	>2		>0.5	>0.5	>0.5		
Ertapenem				>0.5	>0.03													
Erythromycin				>8										>0.5	>0.5	>1	>0.5	>0.5
Florfenicol	>4	>1					>4	>2		>2	>1							
Fusidic acid														>0.5	>0.5	>0.5		
Gamithromycin		>4									>4							
Gentamicin				>2	>2	>2			>2			>8	>2	>1	>1	>2		
Imipenem					>0.5													
Linezolid																>4		
Meropenem					>0.12	>0.12							>0.12					
Nalidixic acid					>8								>8					
Neomycin						>8			>4									
Nitrofurantoin						>64								>32 (UTI)	>32 (UTI)	>32 (UTI)		>32
Oxacillin														>0.25	>1			
Oxolinic acid	>0.12						>0.25	>0.25										
Oxytetracycline	>1						>0.25	>0.12										
Penicillin		>1								>0.5	>0.5			[b]	[b]	[b]	>0.12	>0.06
Sulphamethoxazole					>64								>256					
Temocillin					>16													
Tetracycline		>2		>2	>8	>8			>8	>2	>2		>8	>1	>1	>1	>0.5	
Tiamulin			>0.25															
Tigecycline					>0.5								>0.5					
Trimethoprim					>2								>2			>2		
Trim & sulph.[a]		>0.25				>0.5			>0.5		>0.12			>0.5	>0.5	>0.25	>0.25	>0.5
Tylosin			>16															
Tylvalosin			>1															
Valnemulin			>0.12															

[a]Concentration of trimethoprim given, tested with sulphamethoxazole in concentration ratio 1/20; [b]beta-lactamase production; [c]EUCAST ECOFFs are used for MRSA (clindamycin >0.25).

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SWEDRES|SVARM 2023

This annual report describes the monitoring of antibiotic resistance and antibiotic sales in human and veterinary medicine in Sweden in 2023.

From an international perspective, the situation in Sweden regarding antibiotic resistance in bacteria from humans and animals is favourable. In spite of this, there are still problems with cross infection and increasing resistance. Thus, the preventive efforts must continue, and in some instances be intensified.

The total sales of antibiotics for both humans and animals have decreased continually from a long-term perspective, and prescribers' choices of antibiotics are broadly in line with policies and recommendations.

The number of cases of $ESBL_{CARBA}$ in humans is low in Sweden. In 2023, the number of cases with $ESBL_{CARBA}$ increased significantly to 314 cases, compared to 240 in 2022. The risk of introducing $ESBL_{CARBA}$ among vulnerable patients is very concerning as this could have serious consequences for these patients. So far, $ESBL_{CARBA}$ has never been confirmed in samples from domestic animals in Sweden.

The efforts to optimise antibiotic use, prevent infections, and minimise dissemination of antibiotic resistance are now back at pre-pandemic levels. It is increasingly important to address the slow pandemic that antibiotic resistance constitutes.

Focus areas:

- ECDC PPS 2023: Antibiotic use in acute-care hospitals in Sweden
- Ongoing activities to improve access to antimicrobials
- Council recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach
- Sales of antibiotics for group treatment of post-weaning diarrhoea in pigs
- SvarmPat – monitoring of resistance in pathogens from farm animals

The Public Health Agency of Sweden (PHAS) has a national responsibility for public health issues. The Agency promotes good public health by generating and disseminating knowledge to professionals involved in the field of public health, including infectious disease prevention.

The Swedish Veterinary Agency (SVA) is an expert authority within the field of risk assessment and diagnostics, as well as the prevention and control of infectious animal diseases. The Agency strives for good animal and human health through research, contingency planning and communication of knowledge.